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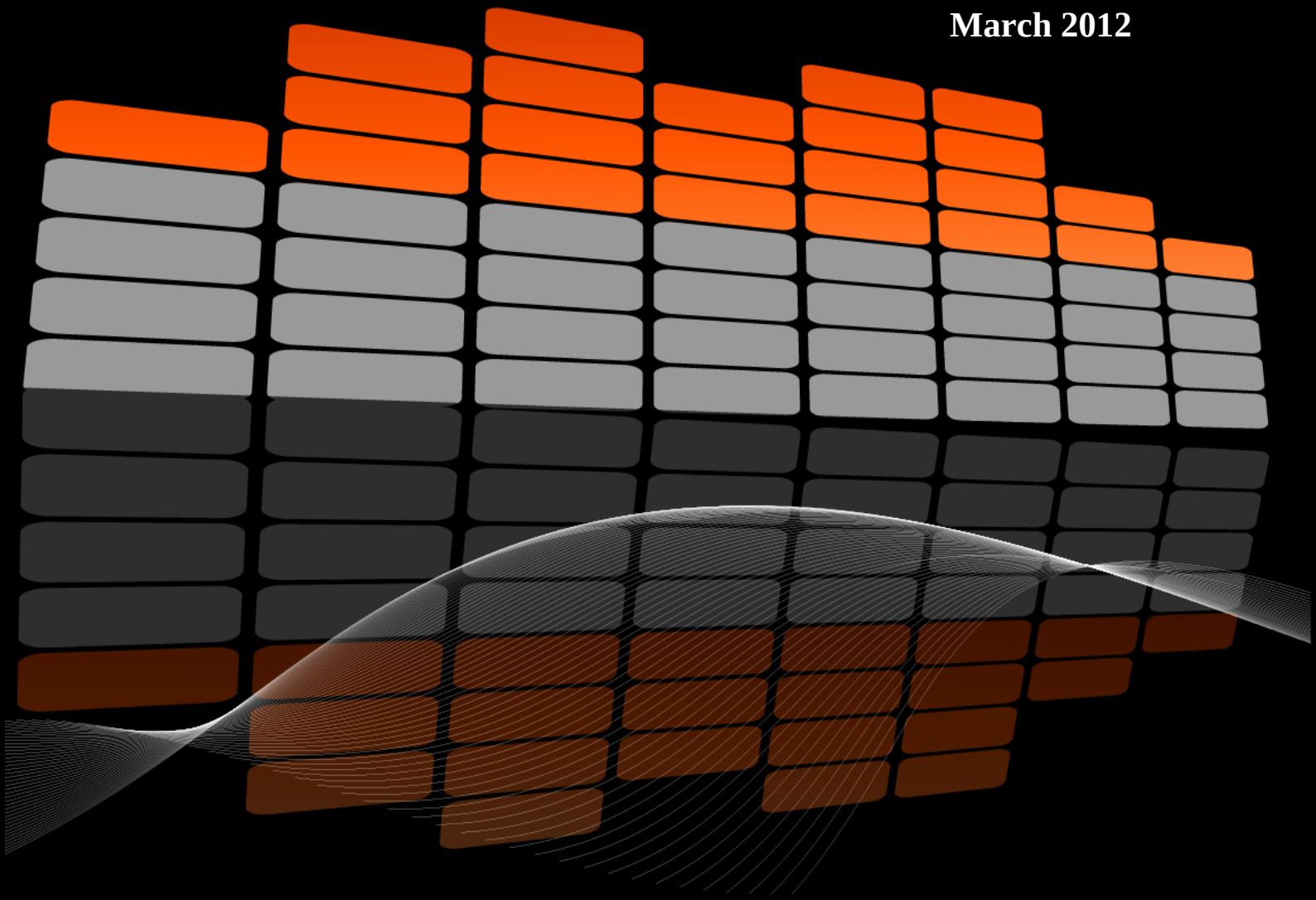

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Fuzzy Logic and Behavioral Finance: An Approach Using Fuzzy c-Means Algorithm

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***Abstract*— The aim of this paper is to show the connection between the behavioral finance theory and fuzzy sets theory. Such connection, little explored by researchers, may produce new models for the financial market, leading to a better understanding of anomalies not explained by modern theory of finance. In this paper two techniques based on fuzzy sets, an clustering algorithm and the fuzzy transform shown incorporate, intrinsically, the heuristics of representativeness and anchoring of the behavioral finance theory**

***Keywords*—** *Fuzzy Sets; Behavioral Finance; Fuzzy Transform; Fuzzy c-Means Algorithm; Heuristics.*

1. Introduction

The financial market can be viewed as a nonlinear and time varying system, subject to numerous events, such as wars, governmental changes and crises arising from natural phenomena. It is a complex system for which many mathematical models have been developed for a better understand of its dynamics. In particular, some models are the essential foundations for two theories of the financial market: the so called traditional finance theory and the behavioral finance theory. The traditional finance theory considers a rational investor operating in a market that reflects all available information. On the basis of this theory, Harry Markowitz developed a model for portfolio selection in 1952 (Markowitz, 1952) and William Sharpe developed the capital asset pricing model (CAPM) in 1964 (Sharpe, 1964). In 1970 Eugene Fama presented the theory of efficient market hypothesis (Fama, 1970), whereby the market is classified as informationally efficient in the weak form, semi-strong form or strong form. Contrasting the claims of traditional finance theory, the behavioral finance theory proposed by Kahnemann and Tversky (1974), Nobel laureates in economics in 2002, states that the individual is not fully rational and operates in a market that does not reflect all available information, but their decisions are biased by rules of thumb or heuristics, such as representativeness, anchoring and availability. Since then, some models were developed based on behavioral finance theory, supporting the idea that the individual is not fully rational and operates in a market not rational. Such models suggest that the stock market, due to biased decisions of investors, produces effects known as overreaction and underreaction. Assuming the influence of the behavioral finance heuristics, DeBondt and Thaler (1985) detected the phenomenon of overreaction in the U.S. stock market. The findings of Kang and others confirm overreaction in short term and underreaction in medium term in the Chinese stock market (Kang, Liu and Ni, 2002) Aguiar and Sales, using an algorithm based on fuzzy sets theory, detected the existence of overreaction in the U.S. stock market as influence of heuristics in the decision making of investors. Beyond the methodology based in the fuzzy sets theory proposed by Aguiar and Sales, the fuzzy sets theory has been widely applied in the analysis of the financial market, as can be observed in Liginlal and Ow (2006), Khcherem and Bouri (2009), Mohamed, Mohamad and Samat (2009). Supporting the application of the fuzzy sets theory in the financial market, Peters (1996) states that there is a strong connection between the fuzzy sets theory and behavioral finance theory, motivating the main focus of the present work: the development of a theoretical context for the connection between fuzzy logic and the theory of behavioral finance. It is noteworthy that a preliminary version of this work was published in (Aguiar and Sales, 2011)

This paper is organized as follows: In section 2 a brief review on fuzzy sets theory and the concepts of fuzzy clustering and Fuzzy Transform are presented; an introduction to behavioral finance theory is presented in section 3. In section 4 the main contribution of this paper is presented, that is, the connection between fuzzy sets theory and behavioral finance theory; the conclusions are presented in section 5.

2. Fuzzy c- Means Algorithm

The fuzzy set theory proposed by Zadeh (1965) possesses as one of its main characteristics the fact of allowing the treatment of linguistic variables, such as hot, very hot, high, low, advisable, not advisable, highly risky, etc.

The resulting property when considering linguistic variables to characterize objects is that, instead of belonging or not to a certain set, as stated by the classic set theory, these objects will have pertinence indexes associated with different sets. A detailed presentation of the main concepts of the fuzzy theory can be found in Zimmermann (1996).

Definition 1: Let the set $X = \{x_1, x_2, \ldots, x_m\}$, $C_1, C_2, \ldots, C_n$ subsets of set X and real numbers $0 \le \mu_i(x_j) \le 1, i = 1,2,..n$, $j = 1,2,\ldots,m$, such that, for every $j = 1,2,\ldots,m$, one has $\sum_{i=1}^{n} \mu_i(x_j) = 1$. Under these conditions, $\mu_i(x_j)$ is denoted membership degree of the element x_j with respect to fuzzy subset C_i. These subsets can be represented by mathematical functions, called membership functions and defined in a certain interval of real numbers. So, the membership degree obtained through of these membership functions may be understood as a measure of the degree of affinity, similarity or compatibility among elements and a subset C_i.

Among the techniques for obtaining of the membership degree of an element with regard to the subsets are highlighted: techniques of grouping or classification of elements in subsets of a given set (clustering analysis) (Amir and Ganzach, 1998; Bezdek, 1981), rules IF and THEN defined by an expert for classify an element in regard to subsets through of the membership degree

The Fuzzy c-Means (FCM) algorithm (Bezdek, 1981) is a clustering method in which the elements represented by some attributes are classified into more than one group simultaneously. Each group is represented by a center vector and, the distance of each element with respect to the center of the group indicates the similarity between the group and the element.

Considering, for example, m elements represented by set $X = \{x_1, x_2, \ldots, x_m\}$ and c clusters, the aim is find c-partition of X exhibiting homogeneous subsets. Assuming an element x_j and a group represented by center vector c_i, $\|x_j - c_i\|$ is defined as the distance between an element and a group. The stronger the proximity of an element to a given subset, that is, the shorter the distance between an element and the center of a given subset, the closer will be the membership degree to the unity of that subset.

The quadratic distance weighted by the membership degree $[\mu_i(x_j)]^m$ produces the objective function represented in (1), which must be minimized.

$$J(U,c) = \sum_{i=1}^{n}\sum_{j=1}^{m}[\mu_i(x_j)^2 \|x_j - c_i\|^2] \quad (1)$$

where U is a fuzzy c- partition of set X and c is the set of cluster center.

The optimization problem given by (1) can be solved analytically, and the solution is given by Bezdek (Bezdek, 1981):

$$c_i = \frac{1}{\sum_{j=1}^{m}(\mu_i(x_j))^2} \sum_{j=1}^{m}(\mu_i(x_j))^2 x_j \quad \text{i} = 1,\ldots\ldots\text{n} \quad (2)$$

$$\mu_i(x_j) = \frac{\left(\frac{1}{\|x_j - c_i\|^2}\right)^{1/(m-1)}}{\sum_{k=1}^{c}\left(\frac{1}{\|x_j - c_k\|^2}\right)^{1/(m-1)}} \quad j = 1,\ldots\ldots,m, c = 1,\ldots,n \quad (3)$$

As one can well observe, the calculation of the vectors of center c_i, given by (2) depends on the membership degrees $\mu_i(x_j)$. These, in turn, depend on c_i, according to (3). The solution can be obtained iteratively by the FCM algorithm, as described below (Bezdek, 1981; Zimmermann, 1996).

Step 1: Initiate the membership matrix in such a way that $\mu_1(x_j) + \mu_2(x_j) = 1$, $j = 1,2,\ldots,m$ and $\mu_1(x_j) \ge 0$ and $\mu_2(x_j) \ge 0$, $j = 1,2,\ldots,m$;

Step 2: Calculate the centers c_i, using (2);

Step 3: Recalculate the new membership matrix via (3) by utilizing the centers obtained in step 2;

Repeat steps 2 and 3 until the value of the objective function represented by (1) does not

decrease any longer according to the adopted precision. For achieve the global minimum of square-error it takes run the algorithm with different initial partitions until the final partition no more change.

Among the techniques for grouping or classifying elements in subsets of a given set, the Fuzzy c-Means – FCM algorithm has been proved to be an effective tool in those cases in which the features or attributes of the analyzed elements can be represented by a vector of real numbers. In such cases, the FCM algorithm allows identifying clusters of elements from a $n \times p$ matrix, being n the number of elements and p the number of features of these elements, and simultaneously determines membership degrees associated to each element (Zimmermann, 1996). Each cluster is represented by a center, c_i, and the distance of each element in regard to each center defines the membership degree $\mu_i(x_j)$ of the element related to that cluster.

As an example, consider the pattern matrix M formed by six lines (6 objects) and two columns (2 features).

$$M = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 2 & 1 \\ 2 & 3 \\ 4 & 1 \\ 4 & 3 \\ 5 & 2 \end{bmatrix}$$

Applying the FCM algorithm in this data set in order to form two groups, the following data shown in table 1 were obtained:

Observing table 1, note that the smaller the distance of an element with regarding to the center of a particular cluster, the less membership degree in regarding to this group. For example, considering the element xi formed by the ordered pair (1, 2), it is observed that the distance of this element in relation to group 1 is smaller than the distance in relation to group 2 and, consequently, the greater the membership degree of the element xi in relation to group 1.

The clusters are formed from the matrix membership degrees randomly chosen, according Step 1, grouping the elements by similarity measure based on the distance of each element relative to each center. In this case, after several iterations, the vectors of the center are adjusted to produce the final group and, consequently, the final matrix of membership degrees. This means that the element x_i is more similar to the group 1.

Table 1. Application of Fuzzy c-means Algorithm

Data Matrix			I. MEMBERSHIP Degrees		Distance	
			Cluster 1	Cluster 2	Between the Object and Center Vector of Cluster 1	Between the Object and Center Vector of Cluster 2
X_1	1	2	0.9630	0.0370	0.6552	3.3448
X_2	2	1	0.8532	0.1468	1.0574	2.5493
X_3	2	3	0.8530	0.1470	1.0582	2.5450
X_4	4	1	0.1470	0.8530	2.5450	1.0582
X_5	4	3	0.1468	0.8532	2.5493	1.0574
X_6	5	2	0.0370	0.9630	3.3448	0.6552

The center vectors of the cluster 1 and cluster 2 are, respectively, (1.6555; 1.9996) and (4.3448; 2.0004).

One other fuzzy technique, called Fuzzy Transform, developed by Perfilieva (2006), is a transformation between two universes and very useful in many applications, such as image compression, data analysis, and can use several different functions for execute a fuzzy modeling. It´s takes a function and produces a set-to-point correspondence between fuzzy sets from the partition and certain average values of that function.

So, let, $A_1,\ldots..,A_n$ be membership functions on interval [a,b] and a function f belonging to the set of continuos function on interval [a,b]. The n-tuple of real numbers $[F_1,\ldots.,F_n]$ given by (4) is the fuzzy transform of f with respect to $A_1,\ldots..,A_n$.

$$F_K = \frac{\int_a^b f(x)A_K(x)dx}{\int_a^b A_K(x)dx}, \quad K = 1,\ldots,n \qquad (4)$$

The kth component of the Fuzzy Transform minimizes the function showed in (5).

$$\phi(y) = \int_a^b (f(x) - y)^2 A_K(x)dx \qquad (5)$$

where $y = F_K$

Once known the Fuzzy Transform components F_K, it is possible (approximately) to reconstruct the original function f using (6):

$$\bar{f} = \sum_{K=1}^{n} F_K \cdot A_K(x) \qquad (6)$$

Equation (6) is called Fuzzy Transform inversion formula.

More details on the Fuzzy Transform can be obtained in Perfilieva (2006) and Perfilieva, Novák and Dvorák (2008).

3 Behavioral Finance

The modern theory of finance is based on the premise that the investor is rational, risk averse and operates in a market where stock prices reflect all available information. The research developed in (Fama, 1970), Markowitz (1952) and Sharpe (1964) present the fundamental bases for the development of the modern theory of finance.

On the other hand, according to the behavioral theory, individuals make decisions biased by heuristics, with a rationale that deviates from statistical rules. Cognitive psychology, which studies the mechanism of thought, is the basis of this approach and shows that individuals value too recent experience and are overconfident in their own abilities, providing thus the emergence of distortions in their thinkings (Ritter, 2003).

Among the heuristics of the behavioral finance, the representativeness and anchoring are heuristics of particular interest for this paper and are briefly described below:

i) Heuristic of representativeness: refers to a kind of mental shortcut in which there is a tendency to assume that something belongs to a particular group, based on the similarity with a member of that category. Many probabilistic questions with which people are concerned are: what is the probability that the object A belongs to Class B? What is the probability that event A originates from process B? To answer these questions people use the representativeness heuristic, in which probabilities are assessed by the degree to which A is representative of B. In a classic example of literature, some individuals must answer what is the occupation of a person from a group of ten people, knowing that eight people in the group are truck drivers and two are brokers. In the first case the ten people are equally dressed and, after choosing randomly one person from the ten participants, based on the known probability, judged that this person would be a truck driver. In the second case, an element of ambiguity was added: the ten people were dressed differently and, when a person was chosen a person, wearing suits, sunglasses and carrying a folder. In this case, most participants identified this person as a broker, although the likelihood of this person be a truck driver to overcome the likelihood, known a priori, to be a broker. In this example, the man wearing suit, goggles and carrying a folder has more similarity to the set of brokers and less similarity to the set of truck drivers. The individuals make an association based on similarity, without conducting an analysis of the structure of probabilities, responding that the person selected was a broker (Peters, 1996). In the context of decisions on the economy, the individual under the influence of the representativeness heuristic has a strong tendency to overvalue recent information. As in the previous example, there is new ambiguous information that reduces the accuracy of the analysis, thereby producing a biased decision (Amir and Ganzach, 1998). The existence of such heuristic in decision making tends to produce over-reaction, meaning that past losers tend to be winners in the future and vice versa (Fama, 1998).

ii) Heuristic of Anchoring: refers to a kind of mental shortcut which verifies the use of a standard as a starting point, adjusting decisions on the basis of this initial anchor. In many situations individuals make estimates supported by an initial value, which is adjusted to produce the final answer. The initial value may be suggested by the formulation of the problem or may be the result of a calculation. An experiment conducted by Tversky and Kahneman (1974) shows the influence of anchoring in the decision of an individual. In this experiment, two student groups must estimate the value of an expression in five seconds:

$8\times7\times6\times5\times4\times3\times2\times1$ for the group 1;

$1\times2\times3\times4\times5\times6\times7\times8$ for the group 2.

Although the correct answer to the two sequences is 40.320, the average estimate obtained for the sequence 2 was 512, while the average estimate obtained by the group 1 (descending sequence) was 2.250. This occurs because in the descending sequence the first steps of multiplication (from left to right) produce a number greater than the ascending sequence. Thus, when individuals are faced with complex situations, they use to make decisions supported by the information available. In the stock market, where the amount of information is very extensive and dispersed, individuals tend to use mental shortcuts, or heuristic judgments in decision-making, transforming a complex trial in a simple task. The heuristic of anchoring is usually present when decisions are based on facts or terms of reference It is associated to conservative decisions, causing people to resist sudden changes in their decisions when faced with new information (Peters, 1996).

In terms of stock investments, market prices are usually a reference in the decision of an investor, since the information is extensive and scattered. The existence of such heuristic in decision making tends to produce sub-reaction, in which past winners tend to be future winners and losers in the past tend to be losers in the future (Fama, 1998).

4 Fuzzy c- Means Algorithm, Fuzzy Transform and Behavioral Finance

In this section the connection between the behavioral finance theory and the theory of fuzzy sets is explored. More specifically, it is shown that the fuzzy c- means (FCM) algorithm incorporates, intrinsically, some heuristics of the behavioral finance theory.

Concerning the heuristic of representativeness, it is present in the fuzzy clustering algorithm in the separation and grouping of objects. The groupings are made based on the similarity of each object with respect to each group. In the same way, the representativeness heuristic is mainly based on the similarity between objects as described in section 3.

As an example, the figure 1 shows the distribution of 100 random data, each one with two characteristics.

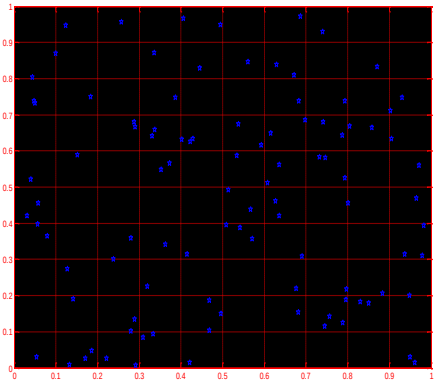

Figure 1. Data Matrix

Applying the FCM algorithm to this data set a clustering consisting of two groups is obtained as shown in figure 2.

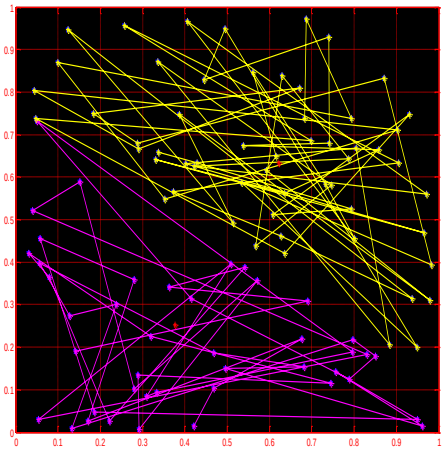

Figure 2. Clustering Fuzzy

Clearly, elements more similar in the sense of their membership degrees are grouped. This grouping occurs due to the heuristic of representativeness contained, intrinsically, in the fuzzy c- means algorithm that, based on the similarity between the objects and each group, assigns a membership degree to each element with regard to each cluster.

The anchoring heuristic is also present, intrinsically, in the fuzzy c- means algorithm. As already defined in section 3, a decision based on this heuristic is adjusted for an anchor, in other words, an initial value used to produce the final answer. Similarly, as described in the section 2, the first step of the algorithm starts with a matrix of membership degrees that will be adjusted at each iteration of the algorithm, to produce the final answer or the final grouping.

Since the fuzzy c- means algorithm is based on fuzzy sets theory, there is a strong connection, or a great similarity between the fuzzy sets theory and the theory of behavioral finance. In the model developed by Aguiar and Sales, called Behavioral Fuzzy Model (Aguiar *et al*, 2008), stocks of the financial market are classified by fuzzy c-means algorithm and two groups (winner and loser) are defined, being each group represented by a center. The grouping of the stocks is based on the similarity of each stock with regard to the center of each group, forming a winning stock portfolio and a loser portfolio. Aguiar and Sales find that the Behavioral Fuzzy Model is biased by representativeness and anchoring heuristics in decision making (Aguiar *et al*, 2008), exploring, in this way, anomalies (overreaction or underreaction) present in the stock market. In Aguiar and Sales (2010), applying the methodology developed em (Aguiar *et al*, 2008) in the American stock market, the link between fuzzy logic and behavioral finance was found in the practice.

Similarly, there is an apparent connection between the behavioral finance theory and the theory of fuzzy sets. More specifically, the Fuzzy Transform possesses, intrinsically, some heuristics of the behavioral finance theory.

Concerning the representativeness heuristic, it is present in the Fuzzy Transform in the following sense: as can be seen in (4), the components of the Fuzzy Transform are the weighted mean values of the given function, where the weights are gives by the membership degree, $A_K(x)$, obtained through of the membership functions. The membership degree represents the similarity of each object with regard to each group. Surprisingly, the representativeness heuristic is mainly based on the similarity between objects as described in the section 3.

The anchoring heuristic is also present, intrinsically, in the Fuzzy Transform in the following sense: a already defined in the section 3, a decision based on this heuristic is adjusted for an anchor, an initial value used for produce the final answer. Similarly, as described in the section 2, the components of the Fuzzy Transform must minimize (5); otherwise the components are not valid. Thus, (5) represents an anchor for the Fuzzy Transform.

Since that the Fuzzy Transform is based on fuzzy sets theory, there is a strong connection, or a great similarity between the fuzzy sets theory and the theory of behavioral finance. In the methodology developed by Perfilieva, Novák and Dvorák (2008) the Fuzzy Transform is utilized for detection and characterization of dependencies among attributes. In Perfilieva, Novák, Dvorák, (2008) was created an optimal mathematical model of the gross domestic product (GDP), in other words, was founded a minimal set of attributes that determine the dynamic of the GDP. The results showed that the GDP can be represented by just three variables: gross product, gross capital and final consumption.

Of course, the Fuzzy Transform may be utilized in the financial market for forecast, dependence analysis and portfolio formation, allowing to explore the anomalies (overreaction or underreaction) present in the stock market (Ritter, 2003; Sharpe, 1964), once that the Fuzzy Transform has biases contained in the behavioral finance theory. The connection between fuzzy logic and behavioral finance evidenced in this paper, not only serve as a demonstration of approach of fuzzy techniques in stock market, but also for provide new methodologies for to model and analyze the stock market.

5 Conclusion

Many models have been developed to assist and improve the performance of investors in decision making. Some models, based on the theory of modern finance, assume that the investor is rational and risk averse. On the other hand, behavioral finance theory claims that the investor is biased by heuristics, such as representativeness, anchoring and availability in the decision making in the stock market.

This paper shows the strong connection between fuzzy sets theory and behavioral finance. The comparison between these two theories shows that two fuzzy techniques, called fuzzy c- means (FCM) algorithm and Fuzzy Transform (F- Transform), which has constructive base in the theory of fuzzy sets, incorporates, intrinsically, the heuristics of representativeness and anchoring derived from the theory of behavioral finance.

Thus, a model for the financial market that has as constructive base the theory of fuzzy sets, leads an investor to make a biased decision by heuristics of representativeness and anchoring. The presence of these heuristics in decision making of an investor can produce some anomalies in the stock market, known as overreaction and underreaction.

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Momentum and Reversals: An Alternative Explanation by Non-Conserved Quantities

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***Abstract*— The momentum effect in stock trading means that stocks performing well in the past will do so in the future, too. A recent (seemingly) proof of it would be a big discovery: Stock prices would obey laws similar to the Newtonian equation of motion. However, using the recent result that stock prices are distinct from stock values, the whole mystery disappears without a trace. Stock prices fluctuate chaotically (in a mathematical sense). Therefore the momentum within stock prices is easily explained by a self-fulfilling prophecy as long as enough people believe in it. In the recent experimental "proof" of the momentum effect, stocks had been traded thousands of times. In generalizing the well-known average cost effect, we give a second quantitative explanation for the observed results.**

***Keywords*—** *Momentum, chaos; intrinsic value; conserved quantity; average cost method.*

1. Introduction

The *efficient market hypothesis* is one of the tenets of finance theory. In its strongest form, it postulates that past price movements should give no useful information about the future ones. Therefore investors should have no logical reason to prefer the winners of any period to the losers, because both should be priced fairly already (Dimson et al. (2008)). The efficient market hypothesis applies the classical theories of competition to finance by stating that competition among rational investors determines prices, so that they reflect the consensus estimate of fair value in the light of all available information. Despite the growing evidence on price distortions in forms of e.g. systematic mispricing, periodic price bubbles and collapses and levels of volatility vastly greater than the underlying dividend streams, the efficient market hypothesis has remained the dominant paradigm in finance (Vayanos and Woolley (2009)). However, the latest capital market booms and crashes, culminating in socially costly crisis like the one starting in summer 2007, have discredited the idea that markets are efficient. In consequence, the conception that prices reflect fair values has to be questioned (Vayanos and Woolley (2010)).

One of the conundrums in this area is the so called momentum effect (cf. Fama and French (1993), The Economist (2011)). In short is says that a stock having behaved well in the past will do so in the future, too. It has a "moment of inertia", just like a massive body. If that is true, just picking last year's best performing stocks should be a good advice. It is of course in contrast to the standard advice of choosing undervalued stocks, which most likely performed lousy recently.

A very thorough analysis of the momentum effect has been performed lately by Dimson et al. (2008). In many different stock markets, partly dating back over more than a hundred years, the authors simulated the following: Based on the stocks' last 12 month-performance, each month the stock market was separated into three classes

1. *Winners*, i.e. the 20% of best performing stocks.
2. *In-betweens*, i.e. the 60% of medium performing stocks.
3. *Losers*, i.e. the 20% of worst performing stocks.

From each of these classes, only the best performers (of the last 12 month) were bought. After a holding period of one month, the three stocks were re-sold and three new ones were bought, choosing again the best performers from the three classes and so forth. Doing that (in simulation) for many years (sometimes over a hundred years), luck or coincidence could be excluded. The results were impressive, the returns of

the three classes in almost all cases showed the same pattern: Excellent performance of the winners, mediocre performance of the in-betweens and lousy performance of the rest.

Nonetheless, Dimson et al. (2008) did not discover a recipe for becoming rich. In reality, prices will adjust due to the buying and selling of many people. But, at first glance, the outcome is puzzling from some other point of view: It seems to prove that there is something like a "*moment of inertia*" in value. One may even find the optimum observation period. Say observing for 10 months only and buying and selling every 25 days. From this, one may get something like a fictive mass. And one may create something like a Newtonian equation of value, similar to the real Newtonian equation for the position of a mass point.

The whole thing turns into the conundrum mentioned above, if one realizes that a stock is a piece of a company. A real company consists of a very complicated network of buying, producing and selling. In the end, it (hopefully) delivers worth, i.e. *added value*. Management science tries to map this complicated arrangements into even more complicated equations. The success however is pretty limited due to complexity. And all this can be condensed in the above mentioned Newtonian-like equation? Indeed that looks like standing in the eve of discovering something as fundamental as quantum mechanics. This justifies people's enthusiasm when seeing hints for a momentum effect.

In actuality, there is a fundamentally wrong assumption in the line of argumentation above. It is supposed that the stock price has a good correlation (at least in the long run) with the performance of the underlying company. In a recent paper, Appel and Grabinski (2011) however showed clearly that there is no such correlation: There is *intrinsic value*, which is a conserved quantity. It is essentially given by the cash the company will generate in the future. In contrast, there is *market value*. It is not conserved and it may *fluctuate chaotically* in the mathematical sense. (A more detailed summary of the author's findings is given in chapter 2. It explains the relatively new tenet of conserved and non-conserved quantities in management sciences). All of momentum's mystery vanishes without a trace, if (future) investment decisions are based on non-conserved (historic) market prices, given that the latter can fluctuate chaotically under certain circumstances. It becomes obvious that the momentum effect is easily explained as a big self-fulfilling prophecy. For centuries people bet on the lately winning horse. This is especially true for the stock market. There are even so called finance advisers advertising such strategies. (More details will be stated in chapter 3).

Having taken away the mystery of momentum effects, there is even another (statistical) explanation of the experiment of buying and selling stocks based on their last performance: Each time a stock is bought, it is not bought in a fixed number. Rather a fixed amount of money buys as many stocks as possible. At each transaction, the investor gains due to the average cost effect. This extra gain is proportional to the square of the fluctuation in price. The fluctuations of good performing (interesting) stocks tend to be much higher than the fluctuations of low performing (boring) ones. At least partly the results of Dimson et al. (2008) are explained by this special version of the well-known average cost method. Of course it delivers real extra money, which however is (usually) consumed by trading fees. (The average cost effect is covered in more detail in chapter 4).

2. Conserved values versus chaotically fluctuating market prices

The essence of Gutenberg's systemic approach (1998) is that a business situation can be described by a function of certain variables. The systemic approach was borrowed from the natural sciences. It has three ingredients:

1. The *existence of a function is hypothesized*, which potentially reflects the outcome of a system (= business).

2. *Proper variables* are to be identified.

3. Given the fulfillment of these two steps, one may try to *find the function and discuss its behavior*. This third step is the main subject of management science. Arguably it is its very definition.

While the first step can just be assumed, the second one - *finding proper variables* - requires further investigation: In management sciences, up to our knowledge, Appel and Grabinski (2011) initially addressed this issue. They showed *conserved quantities* being the only proper variables for describing the system performance, no matter whether or not the system's characteristic is natural

scientific or managerial. Though, from a pure mathematical point of view, the behavior *of non-conserved quantities* is completely deterministic, they may change unpredictably. This effect is called "chaos" (cf. Schuster (1984)). It is the reason why non-conserved quantities are improper for describing anything (cf. Grabinski (2007)). Non-conserved quantities namely tend to step-ups, i.e. marginal changes at the outset are amplified throughout the system and thereby may lead to drastic deviations towards the expected outcome (cf. "*butterfly wing effect*").

Researching chaos in management or economics is relatively new (cf. Ferreira et al. (2010), Filipe et al. (2010) and Grabinski (2007, 2008)). Yet the market or exchange value has been proven to reflect the archetype of a non-conserved economic quantity (cf. Grabinski (2007), Appel and Grabinski (2011)). Therefore building a business on observing and predicting (trends of) non-conserved market values is as ludicrous as accepting the calculation of next week's lottery numbers as a business (cf. Grabinski (2007 and 2008)).

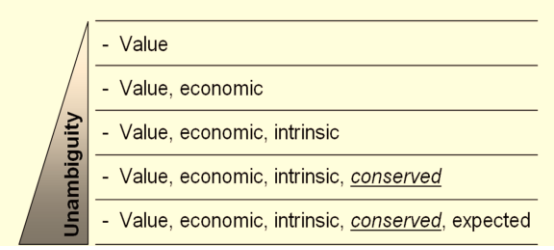

Figure 1: Progressive refinement of intrinsic value (Appel and Grabinski (2011))

The definition of (intrinsic) value must not be confused with a philosophic sense, where the intrinsic value of something is said to be the value that it has "in itself", or "for its own sake", or "as such", or "in its own right", and extrinsic value is value being not intrinsic (cf. Zimmermann (2007)). Rather it should be understood in an economic sense as "*value-in-use*", which is the conserved net cash flow generable in course of the acquisition and application of an asset, adjusted for the expected risk, uncertainty, inflation, currency exchange rates (if applicable) and the asset's obsolescence during its period of use (Appel and Grabinski (2011)).

Any variable - e.g. the net cash flow - can be declared "*conserved*" based on two prerequisites adopted from the sciences (cf. "law of conversation of energy"):

1. There is a *cause for any change of the variable under consideration*. (Therefore capable business analysts have to understand the drivers of the requirement for an asset's utilities as well as their magnitudes).

2. There is a *simultaneous reaction in another conserved quantity*. (In business and economics, investments and market changes are to be considered in detail).

Proper variables have been found indeed if both requirements are fulfilled. Being conserved, they will not change without notice; macroenvironmental catalysts affecting the requirement like political, economic, socio-logical, technological, legal, or environmental conditions have to change before (cf. Appel and Grabinski (2011), Hax and Majluf (1984)). Hence, by applying conserved quantities, the description of a system's (= business') future state can be accomplished in line with Guttenberg's approach (1998).

The discrimination of conserved and non-conserved quantities was tested by analyzing the cash generation of several listed companies to calculate their historic intrinsic firm value. It was compared with their historic share price development. The share of the SAP AG (worldwide number 4 software company) showed a typical pattern. It is a good example, because: SAP has the advantage of being big enough to attract speculators. Changes in value are not distorted by big machines or other non-operational reasons. In actuality, SAP's value is essentially given by its future cash flow determined by "real" customer requirements for the software's utilities. This is because in reality, nearly nobody buys a SAP system in course of speculation. That is the reason why SAP's intrinsic value - as defined and calculated by Appel and Grabinski (2011) - did not change very much, though the rest of the world lived through much turbulence.

During the period under consideration, SAP's (intrinsic) firm value never showed such extreme turning points as the market capitalization. In between, the share prices often followed considerable up- and downward trends being long enough to be exploited. Such trends lifted the market capitalization above the intrinsic firm value by multiples ranging from 1.9x to 7.2x. In other words, the conserved part of the daily market price on average amounted to just 24.5% and ranged from 7.2% to 68.4%. It seems appropriate to conclude that SAP's operations could not match the speculators' expectations! (Hence there seems to be no such thing as market values but only market prices). The Compound Annual Growth Rate

("CAGR") of the firm value was 10.2% per annum ("p.a."), the one of the market capitalization just 3.4% p.a. Since any investor has to pay (most likely) overvalued market prices, comparing the underlying intrinsic value of a stock is inevitable in order to detect actually cheap shares instead of being fooled by the noise in the market (cf. Appel and Grabinski (2011), The Economist (2011)).

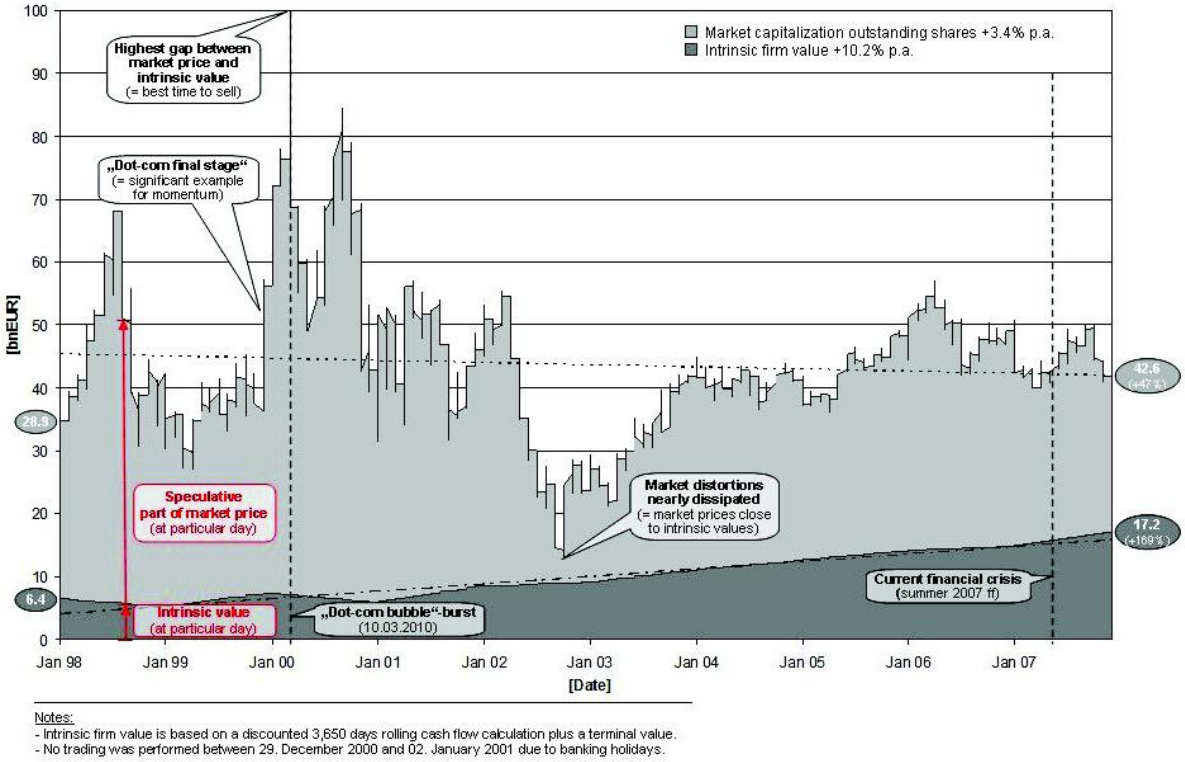

Figure 2: Market capitalization (outstanding shares) vs. instrinsic firm value (10 year rolling forecast), applying the example of SAP

3. Trading non-conserved quantities removes the mystery from the momentum effect

Momentum is the commonly observed propensity for trending in market prices. In the most extreme form, it leads to bubbles and - at times of major reversal - crashes. It has been described as the "premier unexplained anomaly" in asset pricing (Fama and French (1993)). The reason is that, according to theory, the past performance of share prices is no guide to the future; the practice however proves otherwise (The Economist (2011)).

Pure momentum strategies involve sorting stocks into winners and losers, based on past returns over a ranking period. Then winners are bought and losers are sold over a holding period. In well-functioning markets, it should be impossible to rip off profits simply from smart timing of buying and selling assets dependent on their past performance. Yet the most comprehensive momentum study provides extensive evidence that momentum profits were large and pervasive across time and markets. Covering over 108 years of the top 100 stocks, which at today's measure amount to about 85% of the world's equity market capitalization, Dimson et al. (2008) verified that the return of the winners beats to one of the losers by about 10%-points p.a.: Starting 1900 by investing £1 in the winners, more than £4¼ million (14.1% p.a.) could have been gained. Investing £1 in the losers would have grown to £111 (4.36% p.a.) only. The medium 60% show a 9.01% p.a. So the spread between medium to upper 20% is just around four percentage points.

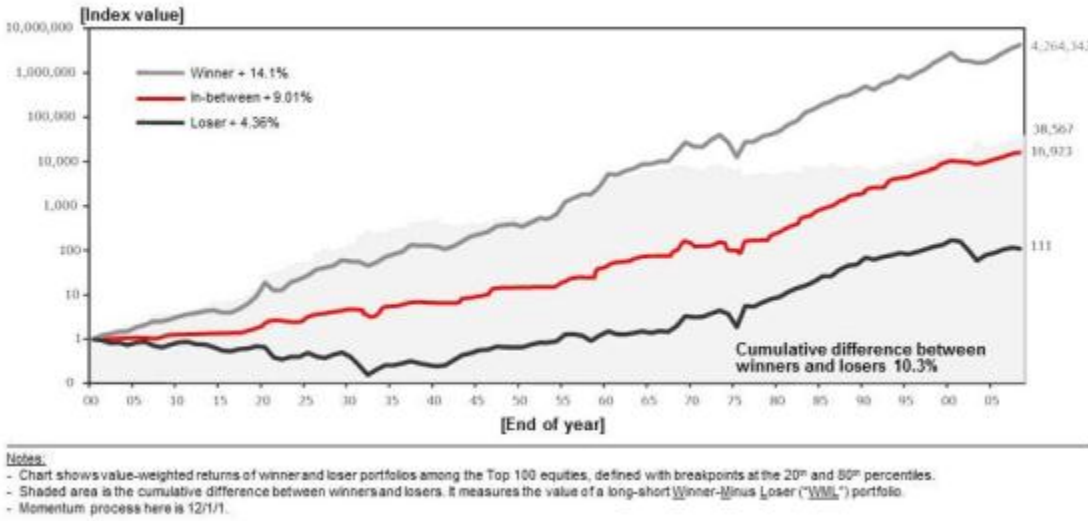

Figure 3: Value-weighted momentum portfolio returns for the Top 100 UK equities, annually from 1900 to 2007 (cf. Dimson et al. (2008))

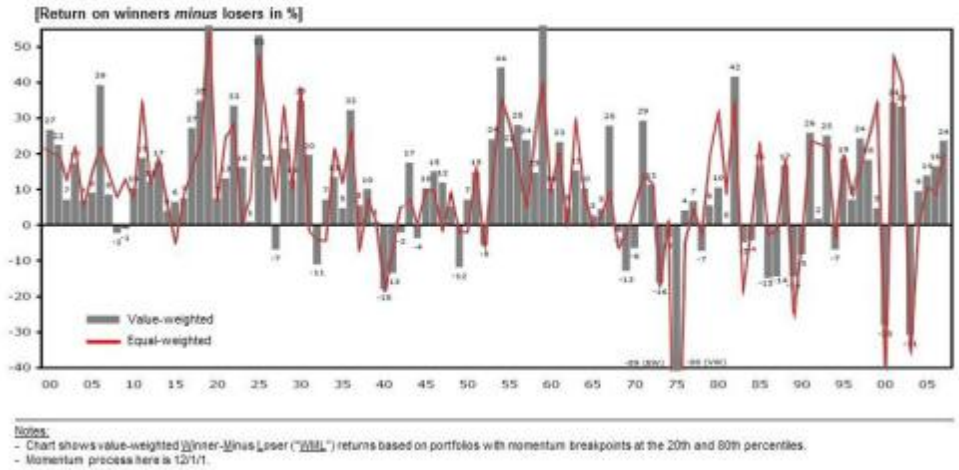

Figure 4: Return on winners minus losers for Top 100 UK equities, annually from 1900 to 2007 (cf. Dimson et al. (2008))

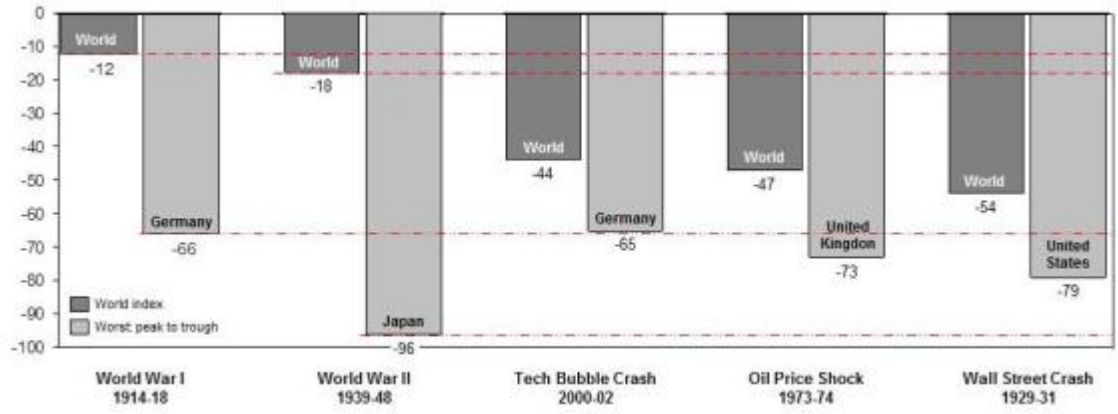

Figure 5: Extremes of equity market history from 1900 to 2007 (Dimson et al. (2008))

Two material limitations however attend trading on momentum:

1. *Transactions costs can seriously dent performance*, because with rebalancing, the turnover can be very high. For example, a 12/1/1 strategy ranks returns over the past 12 months, waits 1 month and then holds for 1 month until rebalancing. For that strategy, winner and loser turnover averaged 31% and 33% per month. (The opposing impact of frequent rebalancing, which benefits momentum returns, is discussed in chapter 4).

2. *Winners underperformed losers in numerous periods*, sometimes by a dramatic margin (cf. Dimson et al. (2008), The Economist (2011)).

Momentum works off the proven premise that stocks having just risen in price are likely to keep on doing so, at least for an exploitable while. But this means, when performing value investing, i.e. picking stocks having low prices compared with intrinsic value of the underlying companies, a large part of the *value portfolio will be at variance to fair value* at any one time (cf. Bright (2009)). Not surprisingly, momentum strategies were not only reversed and falsified numerously, but also in each episode of turbulence, the losses experienced in the worst affected market were disastrous. Interestingly, the three great bear markets damaged the "value" - or rather the price - of the world equity portfolio far more than the world wars (cf. Dimson et al. (2008))! Given that the world wars for sure resulted in more severe breaks of the real (intrinsic) value creation of companies, it is completely unreasonable to assume that any bear market could result in more severe value destruction.

Considering chaos sheds some additional light on both the large performance gap between winners and losers and the "value" destruction in turbulent periods. Up to now, it should be clear that trends in market prices are nothing else than temporary fluctuations of non-conserved quantities. Hence they cannot be foreseen and may be irrational, like demonstrated by Figures 4 and 5. Building on that, our alternative explanation to momentum is:

1. Fundamentals - like the conserved operating cashflow of companies' businesses - add to intrinsic value. Dependent on the market's mood and expectations, they however not necessarily add the same amount to market prices. (Non-conserved) share prices therefore trade regularly above (conserved) intrinsic values.

2. Given expectations drove share prices far beyond intrinsic values, the prices have no fundamental fixture anymore. In such cases, market prices can change chaotically in either direction.

3. *The outperformance of the winner portfolio therefore can be mostly explained by the spreads between intrinsic values and share prices, because they regularly leave ample room for chaotic behavior.* And, because trends in prices may continue unreasonably, the rational advice to any tradesman to buy low and sell high becomes (temporarily) obsolete in the context of trading on momentum.

In a nutshell, in cases of momentum traders outperforming value investors, this is possible mostly because momentum bases on the potentially chaotic behavior of non-conserved market prices. Hence, ultimately, good luck!

4. Average Cost in trading

If somebody buys a certain amount of something at a regular basis, it will amount to N times that amount after N periods. Assuming an *average price* <p> per mentioned amount, one will have spent N times <p> for it. In contrast one may spend exactly <p> each time. The total spending will also be N times <p>. However, because one bought more when the price was low and less when the price was high, the total amount will be bigger. Exactly this is called the *average cost effect*. It is a useful and well-known way if someone is investing regularly in a certain asset. Normally the effect is small, because each time one gains a certain percentage in the order of the squared fluctuation. A similar thing happens by the buying and selling simulated by Dimson et al. (2008). But its effect may be much bigger. First of all, over the very long period, buying and selling happens many times. Second, the fluctuations are big because the average is taken over a long period of time. In order to see how it works quantitatively, we will give a mathematical description of the statement above.

Let's assume to have *two stocks i and j*. Their corresponding prices are:

$$p_i = p_{0i}e^{pt} + \Delta_i(t)$$
$$p_j = p_{0j}e^{pt} + \Delta_j(t) \qquad (1)$$

Their (time dependent) fluctuation is denoted by Δ. The exponential function in front is due to the *compound interest rate* p. (For simplicity, we assume the same average interest rate for both stocks. But this is no real limitation). Starting with say p_i at t = 0 and investing one currency unit, one has at t = Δt:

$$\frac{p_{0i}e^{p\Delta t} + \Delta_i(\Delta t)}{p_{0i} + \Delta_i(0)}$$

For that, one buys the stock j at a price

$$p_{0j}e^{p\Delta t} + \Delta_j(\Delta t)$$

Doing the same at t = 2Δt, 3Δt, 4Δt, and so forth one will end up with equation 2:

$$\frac{p_{0i}e^{p\cdot N\Delta t} + \Delta_i(N\Delta t)}{p_{0i} + \Delta_i(0)} \cdot \prod_{n=1}^{\frac{N-1}{2}} \left(\frac{1 + \frac{\Delta_i((2n-1)\Delta t)}{p_{0i}e^{p\cdot(2n-1)\Delta t}}}{1 + \frac{\Delta_j((2n-1)\Delta t)}{p_{0j}e^{p\cdot(2n-1)\Delta t}}} \cdot \frac{1 + \frac{\Delta_j(2n\Delta t)}{p_{0j}e^{p\cdot 2n\Delta t}}}{1 + \frac{\Delta_i(2n\Delta t)}{p_{0i}e^{p\cdot 2n\Delta t}}} \right) \qquad (2)$$

Defining a *relative fluctuation* Δ_r as:

$$\Delta^n_{r,i,j} \equiv \frac{\Delta_{i,j}(n\Delta t)}{p_{0i,j}e^{p\cdot n\Delta t}} \qquad (3)$$

Eq. (2) can be written as:

$$\frac{p_{0i}e^{p\cdot N\Delta t}}{p_{0i} + \Delta_i(0)} \cdot \prod_{n=1}^{\frac{N-1}{2}} \left(\frac{1 + \Delta_{r\,i}^{2n-1}}{1 + \Delta_{r\,j}^{2n-1}} \cdot \frac{1 + \Delta_{r\,j}^{2n}}{1 + \Delta_{r\,i}^{2n}} \right) \qquad (4)$$

The factor in front (before the *product* Π) is the value by holding stock i without exchanges for a time t = NΔ t. The second factor (with the product Π) denotes the "gain" for the exchanging. Because the relative fluctuation Δ_r can be negative or positive, it is not clear whether this factor is bigger (gain) or smaller (loss) than 1. However, fluctuations as defined in (1) in connection with (3) are symmetric. Taking the additional (admittedly non-trivial) assumption that the fluctuations of stock i and j are uncorrelated, one can show that the second factor is always bigger than 1. In other words, there is a gain due to the average cost method. The simplest way to see how it works is to make a Taylor expansion in the Δ_r's in (4). Of course, all odd powers of Δ_r will vanish (on average). Then one will get in lowest order in Δ_r the following:

$$\frac{p^{p\cdot N\Delta t}_{(0i)e}}{p_{0i} + \Delta_i(0)} \left(1 + \sum_{n=1}^{\frac{N-1}{2}} \left(\Delta_{r\,j}^{2n-1}\right)^2 + \left(\Delta_{r\,i}^{2n}\right)^2 \right) \qquad (5)$$

The next term will be fourth power. It is neglected here. In order to estimate the magnitude, one may define an average quadratic fluctuation by:

$$\Delta_r^2 \equiv \frac{1}{N-1} \cdot \sum_{n=1}^{\frac{N-1}{2}} \left(\Delta_{r\,j}^{2n-1}\right)^2 + \left(\Delta_{r\,i}^{2n}\right)^2 \qquad (6)$$

The gain due to the exchange can be expressed by an *extra interest a* (in addition to p). Using the definition (6) in (5), the additional interest a can be derived from equating:

$$1 + (N-1)\cdot\Delta_r^2 = e^{aN\Delta t} \qquad (7)$$

Solving for a leads to:

$$a = \frac{\ln(1 + (N-1)\cdot\Delta_r^2)}{N\cdot\Delta t} \qquad (8)$$

Equation (8) is the additional interest from the N exchanges. In the experiment described in chapter 3, the monthly exchanges went on for 108 years (N = 1296). With this the plot of (8) is given below in figure 6.

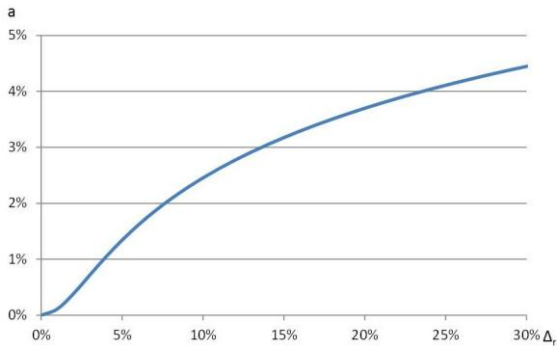

Figure 6: Additional interest rate "a" due to exchanges over 108 years

Figure 6 shows it is easily possible to gain a couple of percentage points due to the average cost method.

Please note that the entire spread from medium 60% to upper 20% was just four percentage points in the simulated performed by Dimson et al. (2008). This is easily explained by an (extra) relative monthly fluctuation of little over 20%.

Of course our extra interest due to the average cost method should be tested with real date. Unfortunately, we do not have access to the particular data of the stocks over 108 years. Just to see how it works in reality, we have taken two quite independent stocks, namely AFL (American Family Life Assurance Company) and GD (General Dynamics).

Both gained in prices by a factor of around nine between January 1985 and January 1995. So it would have been totally irrelevant which stock to

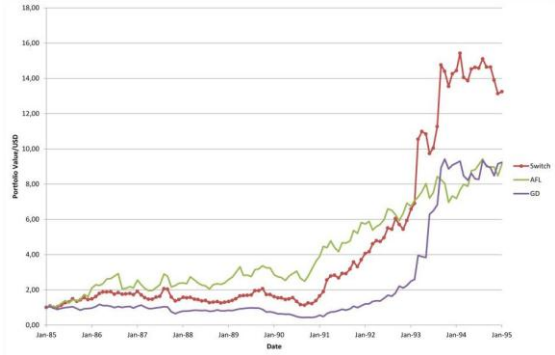

Figure 7: Values of two arbitrary stocks and if exchanged monthly

choose over the ten years. In Figure 7, we have displayed what happened with both stocks individually, and what would have happened, if we had exchanged both stocks monthly over the ten year period. The gain in annual interest is over four percentage points per year. That is an average cost effect. (Please note that the period of ten years considered here is much too short. Though we have 120 monthly values, the major changes are within a few months. Therefore statistical assumptions as taken above are by no means justified).

We close with a short note on whether or not the gain from the average cost method is a real one. Where does it come from? It is real and it comes from all people not dealing in the same way. So if everybody used the average cost method, the market would be distorted and there would not be the purely statistical fluctuations. The same is true, if some people knew about the future market (for whatever reason). Again, the fluctuations would not be by chance any more.

5. Conclusions and next steps

We have clearly shown that the so-called "momentum effect" is by no means a surprise. Because market prices are non-conserved quantities, they may fluctuate chaotically. With it, the momentum effect is easily explained as a giant self-fulfilling prophecy. Assuming that top stocks fluctuate more, at least part of the effect may be due to a generalized average cost effect. (Top stocks fluctuate more, because they are more interesting than the boring middle 60% or the pathological 20% at the bottom. Another line of argumentation is that fluctuation is synonymous with uncertainty here. And uncertainty demands a premium).

As a further proof of our theory, one should take the original stock data of Dimson et al. (2008). Two tests should be performed:

1. Though the time span was long, the question is whether or not particular occasions determined the entire picture more than the time span of a hundred years. As a suggestion, one may take the five (one) percent best and/or worst months out of the data applied for simulation. What happens to the general picture? This test is about the statistics.
2. One should quantify the average cost effect as described in chapter 4. How big is it exactly with the data of Dimson et al. (2008)?

6. Acknowledgements

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Dependence Structure of Equity and Foreign Exchange Markets: Evidence from Industrialized Asian Economies

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Abstract **- The world economy has experienced a number of financial crises over the past 15 years. They placed significant impacts on various countries. This paper attempts to explain the reasons causing the co-movement of foreign exchange market with the stock market in the industrialized Asian economies, including Japan, Korea, and Singapore. We find that the relationship is stronger during the crisis period. Johansen cointegration test result also supports the strong linkage in trading activities between industrialized Asian economies and U.S..**

Keywords - *co-movement, dependence structure, cointegration, stock market, foreign exchange market.*

1. Introduction

Exchange rate is defined as a price of one currency in terms of another. It is one of the most important elements which can impact other financial markets. The fluctuation of foreign exchange rate may be caused by the uncertainty of the world financial economy. Therefore, it leads to the need of examining exchange rate movements, in relationship with the other variables such as stock returns.

The reasons that can affect the co-movement between foreign exchange (FX) and stock markets include financial crisis and the introduction of new financial policy. The financial crises occurred world-wide during the past two decades have significant impacts on different economies directly or indirectly. There are signals of crisis in world economies which affected exchange rates, and followed by the fluctuation in stock market of some countries, such as October Crash in 1987, Asian Financial Crisis in 1997, and Global Financial Crisis from 2007 to 2008. There are many previous researches which studied the relationship between FX and stock markets across countries. Different countries are affected in a different way as their historical, cultural, political and financial backgrounds are not identical. Previous researches also find various results on this relationship by using a large number of models.

This paper aims to investigate the dependence structures between stock and FX markets in three Asian countries, Japan, Korea, and Singapore, over the period of 1994 to 2009. This paper follows the model of Phylatik and Ravazzolo (2005) closely to investigate the relationship between FX and stock markets in these three countries, and compare the results in two crisis periods, Asian Financial Crisis in 1997 and Global Financial Crisis in 2007-2008. Two scenarios as "flow" and "stock", defined in Phylatik and Ravazzolo (2005)'s paper will be considered in the present study. The reason to choose Japan and two newly industrial countries, South Korea and Singapore, is that they have most similar background, in terms of history, cultural, politics, and financial system.

Section 2 is the literature review. It explains the reasons cause co-movement of FX and stock markets and review the existing studies on this issue. It can be divided into Asian Pacific or South East Asian countries and industrial countries. The methodology and empirical tests results are also reviewed to compare whether the results are consistent when using the different tests. The dependence structures between the stock and FX markets are considered to examine the causality to see if the change in stock market leads to the changes in FX market or vice versa. Section 3 introduces the methodology and hypotheses and presents the descriptive statistics of data. It includes a model, which is proposed by Phylaktis and Ravazzolo (2005), and tests of causality and co-integration between variables. Section 4 shows the results from empirical research

and show the trend movement during the past period. The different implications of the government policies across these countries will be reviewed base on the empirical results in section 5. Section 6 concludes the paper and presents the limitation of the present study.

2. Literature Review

2.1 Reasons that lead to co-movement between stock and FX markets

The reasons lead to the co-movement between stock markets and FX markets include financial crisis, changes in monetary and financial policy, change in capital market structure and even a trend of development in world economy. There were some certain crises which affected the world financial economies during last two decades, which destroyed many national economies and caused a deep depression in many countries. These crises can be listed such as October Crash 1987 in the US, Recession in Japan 1992, Financial Crisis 1997 in Asia, etc

First of all, since Black Monday was occurred in October 1987 in US, so-called October Crash 1987, the international independence of stock prices was taken into much attention, which was improved by Eun and Shim (1989), Jeon and Chiang (1996), Lai *et al* (1993), Kurihara and Nezu (2006). Mallaris and Urrutia (1992) studies the correlation among the major stock markets in the world before and after October 1987 crash. They argue that there was no significant correlation before the crisis, whereas significant correlation was found during the crisis and decrease sharply after that.

Since the early of 1990s, Japan has experienced stagnation; even Japan is one of countries has strong influence to the others. During the economic down turn in years of 1990s, the share which used in investment in GDP decreased by 5 percent (Hilpert, 2003). Besides this problem, there were many issues which raised by Japanese crisis during 1990s, such as corporate governance, nearly absence of the productivity growth, etc.

Thirdly, the Asian Financial Crisis in 1997 had a strong impact on some Asian countries during that time. Jang and Sul (2002) conduct a research on the co-movement of Asian stock markets which were affected by Financial Crisis 1997 for 7 countries in Asian. They state that there was no co-movement between stock markets of these 7 countries until Financial Crisis was triggered. This crisis happened by the collapse in the value of Thai baht in July 1997, accompanies with the collapse of stock market following that. It became an Asia Crisis quickly when it spread to all other countries in the region and need to be supported from IMF bailout package. In contrary to effects of decline in stock market and devaluation in foreign exchange rate in Asia countries, they also stated that the stock and foreign currency markets in US and Europe at the same time still had strong performance. Then a question was raised is if all over the world economies has been experienced and affected same as each other from a certain crisis?

Choi *et al* (1998) agree that exchange rate is one of important factors to influence the stock markets. The appearance of newly emerging capital markets all over the world, especially in Asian countries, was received much attention. These emerging markets implement policies and regulations in recent years to facilitate the portfolio investment. Furthermore, capital flows into this area has increased dramatically for recent years, but the current problem is still mentioned about the exchange rate's uncertainty (Carrieri and Majerbi, 2006). The emerging market's financial crises of the 1990s also led to push the stock market booms in Latin American East Asia and Russia (Edwards, 2007). Doong *et al* (2005) examine the dynamic relationship between stock and exchange rate for six Asian emerging financial markets including Indonesia, Malaysia, Thailand, Korea, Philippines and Taiwan. They state that there is a rapid growth in these Asian economies in national income and expansion in capital market. They find a positive relationship between currency and stock markets.

Beside the appearance of new capital market in the emerging economies, the flexible exchange rate regimes in these economies also give a chance to increase the volatility of foreign exchange market and the risk associated with such investment (Phylaktis and Ravazzolo, 2005). Due to the lessons learned in the financial crisis, the choice of currency denomination currency is an important dimension to cover all portfolio decision. Once it changed, it might impact the stock market to secure all positions at that time.

2.2 Relationship between stock market and foreign exchange rate.

2.2.1 General issues

There are familiar results in some cases, which are relevant to time that the crises triggered. Mallaris and Urrutia (1992) find that a decline in relationship

between stock Asian stock markets after the October crash. Najand (1996) took into account the integration of international stock markets during October crash 1987, especially for Asian markets where Japan has much influence on the others. The results indicate that the return of Japan depends on the US performance. In his paper, Najand also argues that Japan is the major stock market which plays a significant role among the other Asian markets not only during but also after the October crash 1987. This result is in contrast with Mallaris and Urrutia (1992), who indicate a decrease in correlation after crisis. On the other hands, Jang and Sul (2002) examine the co-movement of Asian stock markets before, during and after Asian Financial Crisis in 1997 by using data from 1996 until 2000. They selected 7 Asian countries and specified them as direct crisis countries, which are affected by Crisis directly (as Thailand, Indonesia, Korea) and neighboring countries (as Japan, Hong Kong, Singapore and Taiwan). Their results show that there is almost no co-movement in stock markets between 7 Asian countries before crisis, but it increased during financial crisis. However, the strongest co-movement is found in some cases after the crisis (Jang and Sul, 2002). An instability of stock market which caused by Asia Financial crisis is nearly same with the results that October crash 1987 studied by Mallaris and Urrutia (1992), Jang and Sul (2002).

It is widely believed that exchange rate is an important variable to investigate the relationship among stock and FX markets (Choi *et al*., 1998, Homma *et al*., 2005). In the relationship between foreign exchange rates and domestic stock prices, the US stock market is always taken into account to examine its impact on domestic stock prices (Kurihara, 2006). For example, Phylaktis and Ravazzolo (2005) consider the US stock price, which represents the world capital market as an independent variable that can affect the domestic stock prices. It means that US market is one of weighted and influence markets all over the world. Most of local stock markets may change once the US stock market changes. This result is proved by many researches on financial crises (Kurihara, 2006; Phylaktis and Ravazzolo, 2005).

Phylatik and Ravazzolo (2005) show that stock prices are positively correlated with FX markets. Similarly, the current exchange rate and the emerging stock price changes display a highly positive relationship by evidence from India (Mishra *et al.,* 2007). The positive relationship is also found in Japan by Kurihara (2006). He explains this phenomenon by giving evidence that Japan is an exporte oriented-country. That means, an appreciated domestic currency will lead to the increase in foreign exchange rate (Yen/ USD for instance) and followed by the increase in the domestic stock market. In the emerging market, however, the relationship between stock and FX market needs to be reviewed with other macroeconomic variables and it depends on the economic situation (Carrieri and Majerbi, 2006).

2.2.2 Asian countries

A number of studies investigate the short-run and long-run relation between stock and FX markets. Jang and Sul (2002) prove that the relationship between stock markets is not strong enough in long-run because they find that there is a decrease in effects after a crisis. Doong *et al.* (2005) examines relation and pricing between stick and exchange rate for six Asian emerging countries including Indonesia, Malaysia, Philippines, Korea, Thailand, and Taiwan and find that there is no long-run relationship between the stock prices and exchange rates. Similar result is found in Malaysia using a bivariate model (Ibrahim, 2000). Phylaktis and Ravazzolo (2005) also illustrate a temporary effect on the long-rum co-movement of stock and FX markets.

Most of previous researches use Granger test (1969) to examine the causality of linkage between stock and FX markets. Doong et al. (2005) argue that there are no significant casual relations in Philippines and Taiwan. But the bi-directional causality is found in Indonesia, Korea, Malaysia and Thailand. Another study uses data from 7 Asian countries including Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan and Thailand to present a significant causality from exchange rate to stock price in Hong Kong, Japan, Malaysia and Thailand before the Asia crisis 1997 (Pan *et al.,* 2007). Pan et al. (2007)'s empirical tests also confirm the same results for all above 7 countries except Malaysia during the Asian Financial Crisis. However, no country expresses causality from reverse direction during that time (Pan et al., 2007).

Phylaktis and Ravazzolo (2005) introduce "flow scenario" and "stock scenario" with regarding to the sign of coefficient between domestic stock price and foreign exchange rates. They also test the influence of the financial crisis in 1997 on relationship between stock and FX markets and find that the increase in parameters during the period of Asian Crisis was short-lived.

2.2.3 Industrialized countries

Choi et al. (1998) state that foreign exchange rate is an important variable that affects international competitiveness performance of Japanese firms. They try to examine whether exchange rate risk is realized and priced in the Japanese stock market by using unconditional and conditional multi-factor asset pricing models. They find the different results using these two models. The unconditional model result shows that the exchange rate risk is not priced in Japanese stock market and even in US stock market and the pricing result depends on the choice of sub-period, suggesting the time-varying nature to price of the exchange rate risk. However, using conditional models, they find that in major world stock and currency markets, exchange rate risk is priced regardless of exchange rate measured used. It suggests the price of exchange rate risk in Japan is time-varying. Kurihara (2006) analyses the relationship between Japanese stock prices and foreign exchange rate, by adding other macroeconomic factors, as interest rate, into his model. US stock prices are also added into this model to test if it is a significant determinant of Japanese stock prices. Unit root test and the ADF test are applied to check the co-integration between variables and he find that interest rate does not affect much on Japanese stock prices, whereas the impact of exchange rate is positive and significant. Kukihara (2006) also argues that because Japan is an export oriented-country, the domestic currency depreciation is expected to be negatively related to the stock market movement. This finding is in line with Ma and Kao (1990), and Doong et al. (2005). Kurihara and Nezu (2006) include more variables, such as Euro/ Japanese yen's interest rate and the Euro/US dollar interest rate, in their model. The results remain unchanged.

Hyde (2007) seeks to investigate the sensitivity of stock returns at the industry level to market, exchange rate and interest rate shocks in the four major European economies: France, Germany, Italy and the UK by using the methodology of Campbell and Mei (1993). He finds the significant levels of exposure to exchange rate risk in industries in all four markets. Kolari, Moorman and Sorescu (2008) examine the cross-relationship of US stock returns and foreign exchange rate during period from 1973 to 2002. They demonstrate that firms with extreme absolute sensitivity to foreign exchange rate have lower required rates of return than other stocks. Their results suggest that the relationship between expected returns and foreign exchange exposure is non-linear (and inverse U-shaped).

2.3 Methodology used in the existing literature

2.3.1 Co-integration test

Many tests can be used to examine the co-integration between two variables. Unit root test and the methods of the Dickey_Fuller (DF) or Augmented Dickey_Fuller (ADF) are employed to investigate the co-integration and stationary between stock prices and exchange rates in numerous studies (Abdalla and Murinde, 1997; Doong et al., 2005; Homma et al., 2005; Kurihara, 2006; Kurihara and Nezu, 2006). Doong et al. (2005) uses this approach to test the stationary of levels and 1st differences of the stock index and exchange rate; and indicated that all the series of the stock prices and exchange rate are stationary at 1% level for the 1st differences of stock prices and exchange rate (Doong et al., 2005). Moreover, a positive relationship of co-movement between stock and exchange rate market was proved by Kurihara (2006).

Beside ADF test, Johansen trace test (1988) was also employed by Phylaktis and Ravazzolo (2005). In their paper, they introduce the concept of "flow scenario" and "stock scenario" with regarding to the sign of coefficient between domestic stock price and foreign exchange rates. According to the flow scenario, a correlation between domestic stock price and foreign exchange is positive due to its effect on economic activities. On the other hand, the stock scenario indicated that this correlation can be either negative or positive just because exchange rate will have different impacts on the various competing events.

2.3.2 Granger causality test

Many researchers use Granger causality test to check whether the stock returns lead the change in the exchange rate or vice versa (Abdalla and Murinde, 1997; Ibrahim, 2000; Doong *et al.,* 2005; Phylaktis and Ravazzolo, 2005; Pan et al., 2007). Abdalla and Murinde (1997) use the data within the period of 1985 to 1997 on Korea, India, Pakistan and Philippines. They report that the change in foreign exchange rate can make stock price change in Korea, Pakistan, India and the causality from the stock price to exchange rate was found for all sample countries, except Philippines (Abdalla and Murinde, 1997). The results for Philippines and Korea are consistent with those reported in Doong et al. (2005). Ibrahim (2000) indicates that there is uni-directional causality from

stock price to exchange rate in Malaysia and challenges that the causality between those two variables only in the nominal exchange rate, not the real one. However, Pan *et al*., (2007) argues that causality from stock price to exchange rate during the crisis was found for all sample countries, except Malaysia. Wald test is employed by Phylaktis and Ravazzolo (2005) in exploring the causality issues. They test various hypotheses bases on the flow and stock scenarios which have been mentioned above.

2.3.3 Other tests

The univariate GARCH-M and bivariate GARCH-M model for stock returns and exchange rate detect similar results in Doong et al. (2005). They find that the stock returns exhibit significant relation with the changes in exchange rate, except Thailand (Doong et al., 2005). Moreover, all correlations followed by this method are negative. It means that an appreciation in domestic currency leads to an increase in stock prices. Unconditional and conditional multi-factor asset pricing models were used to examine the situation in Japan (Choi et al., 1998). Using stock prices from TOPIC (Tokyo Stock Foreign Exchange), Homma et al. (2005) investigates the relationship between the FX and Japanese stock price by using Arbitrage Pricing Theory (APT). One of their main findings is that stock investors correctly evaluate firms' foreign asset position and appropriately respond to the change of the exchange rate after recession 1992.

In general, the relationship of co-movement between stock and FX markets is different in various countries. Reasons lead to the linkage between those two major variables (stock price and exchange rate) can be listed as crisis, capital flows into emerging markets (countries) and exchange rate regimes. Basically, using different methodology leads to various results. Most of them found the positive relationship between these variables. US stock price is recognised as a significant variable, which is needed to be considered as an influence on domestic stock price; whereas other macro-economic variables such as money supply, interest rate, government policy need to be reviewed (Ibrahim, 2000; Kurihara, 2006; Kurihara and Nezu, 2006).

3. Methodology and Hypotheses

3.1 Methodological issues

3.1.1 General model

This model aims to examine the relationship between domestic and foreign stock and FX markets, which is in line with the model proposed by Phylaktis and Ravazzolo (2005). It is presented as follows:

$$P_t^{domestic} = a_0 + a_1 S_t + a_2 P_t^{US} + \varepsilon_t \quad (1)$$

where

- $P_t^{domestic}$ is the domestic stock price at time t.
- P_t^{US} is US stock price at time t; both express in real term.
- S_t is the real exchange rate, defined as Domestic prices (CPI) relative to foreign prices multiplied by the nominal exchange. Both nominal exchange rate and real exchange rate are expressed in domestic currency against one unit of foreign currency (in this case is the US dollars). ε_t is a disturbance term.

Following the previous studies, all data are transformed by natural logarithms (Phylaktis and Ravazzolo, 2005, Febrian and Herwany, 2007). The exchange rate used in this model is in real term, in order to express a better competitive position of an economy (Chow et al., 1997; Phylaktis and Ravazzolo, 2005). The real exchange rate is computed from nominal exchange rate and consumer price index. The US stock market is usually taken as a leader and preventative of the world economy, who affects the rest of the world's economy fully or partially. In additional, the Japan, South Korea and Singapore markets are assumed to have mid-term to long-term relationship with the US market, so the US stock return is also added in addition to foreign exchange rate.

We will test the relationship between domestic stock prices with foreign exchange rates and US stock prices from 1994 until 2009 using Ordinary Least Square. OLS regression will give some general ideas of whether domestic stock markets have positive or negative relationship with foreign exchange rate. This method has been widely used by previous researches. In the case of Japanese and Singapore, the coefficient of exchange rates changes should be positive (Phylaktis and Ravazzolo, 2005; Kurihara, 2006). When changes in exchange rates (Yen/ USD) increase, it leads to depreciation in Japanese yen and following by promoting exports in Japan. Furthermore, Japan is also well-known as an exported-oriented country; hence an increase in foreign exchange rate causes a rise in domestic stock index. Some previous studies regarding the crisis 1997 argue that the reason that Korea was suffered is

relevant to Japan during the crisis (Khan, 2004, Hayashi, 2006). Therefore, it is most likely to forecast the positive coefficient α_1 as in the case of Japan.

The alpha of US stock return is expected to be positive due to the strong relationship and economics activities between Japan and US (Kurihara, 2006). The current global financial crisis 2007 and 2008, started in the US also affects to the rest of the world, including South Korea. A depress in the US stock markets cause a fall in Korean stock exchange (Kim and Rhee, 2009; Park and Lee, 2009).

3.1.2 Cointegration

On the basic of economy theory, two scenarios, which are relevant to the relationship between the foreign exchange with the domestic stock price index (coefficient α_1), are introduced in Phylaktis and Ravazzolo (2005).

"Flow" scenario is measured on the relationship between the exchange rate and economic activities. Following the explanation in Phylaktis and Ravazzolo (2005), a change in exchange rate impacts on economic activities such as future cash flows, aggregate demand and output, result in the firms' performance, which is relevant to the stock markets. They forecast there is a positive relationship between foreign exchange rate and domestic stock markets. This issue occurs when all information is conveyed to make an increase in the relationship between the US and these three countries, leading to an appreciation in real exchange rate and hence, cause a rise in domestic stock market.

Phylaktis and Ravazollo (2005) give another forecast according to the "stock" scenario. This approach forecast that the relationship between stock markets and exchange rate can be either positive or negative, depends on the relative strength and wealth among their economic activities.

In order to investigate the cointegration between variables, this paper follows the likelihood ratio test in Johansen (1988). Let Y_t is a vector of *P*, *S*, and P_{US} and n is a number of variable in the model (here n = 3). It is said that if Y_t is co-integration, it can be generated as follows:

$$\Delta Y_t = \mu + \sum_{i=1}^{k-1} a_i \Delta Y_{t-1} + a_k Y_{t-1} + \varepsilon_t \quad (2)$$

where:

- μ is a 3 x 1 vector of drift,
- *a* are 3 x 3 matrices of parameters,
- ε is a 3 x 1 noise vector.

The Johansen test statistic, the (n-r) common stochastic trends (trace statistic) is

$$Trace = -T \sum_{i=\gamma+1}^{n} \ln(1-\lambda_i) \quad (3)$$

where:

- λ_i are the (n-r) smallest squared canonical correlations of Y_{t-1} with respect to ΔY_t corrected for lagged and
- *T* is actual sample size (actual number of estimated observations)
- r is co-integration relationship (vector) in model ($0 \le r \le n$).

Then, this paper tests the null hypothesis:

H_{01}: *no integration between variables (r=0), alternative hypothesis will be there is 1 or more co-integration vector (r>0). We calculate* $\lambda_{trace}(0)$*, and*

H_{02}: *there is 1 or less than 1 co-integration vector (* $0 \le r \le 1$*), against the alternative of 2 or 3 co-integration vectors.*

If $\lambda_{trace}(0)$ is exceed the critical value (at significant 5%) of λ_{trace}, meaning that there is no co-integration between variables.

3.1.3 Multivariate Granger causality tests

We will check whether stock price leads to the changes in foreign exchanges or foreign exchange rate leads to the changes in stock prices by using the Granger Causality Test. This paper follows the method used in study of Phylaktis and Ravazzolo (2005), which includes two following steps. First of all, the Wald test is applied to find the lag term of the VAR (k) against VAR (k+1), then applied it on the first k VAR coefficient matrix

$$Y_t = \mu + A_1 Y_{t-1} + \cdots + A_p Y_{t-k} + \varepsilon_t \quad (4)$$

There are three variables in the system, the generated models for Japan, South Korea and Singapore as follows:

$$\begin{bmatrix} P \\ S \\ P^{US} \end{bmatrix} = \begin{bmatrix} A_{10} \\ A_{20} \\ A_{30} \end{bmatrix} + \begin{bmatrix} A_{11}(L)A_{12}(L)A_{13}(L) \\ A_{21}(L)A_{22}(L)A_{23}(L) \\ A_{31}(L)A_{32}(L)A_{33}(L) \end{bmatrix} \begin{bmatrix} P_{t-1} \\ S_{t-1} \\ P_{t-1}^{US} \end{bmatrix} + \begin{bmatrix} \varepsilon_P \\ \varepsilon_S \\ \varepsilon_{US} \end{bmatrix} \quad (5)$$

where:

- A_{io} are the parameters representing intercept terms
- A_{ij} are polynomials in the lag operator L
- P is domestic stock price index for Japan, South Korea and Singapore

At this stage, we can examine the above matrices by using OLS to test the coefficient and a significance of three equations for each country individually, depends on sub-period. As mentioned in Phylaktis and Ravazzolo (2005), the "flow" and "stock" approach regarding to the link between stock and foreign exchange markets is testing through these hypotheses

H1: *"Flow" channel:* $A_{12}(L) \neq 0$, $A_{13}(L) \neq 0$, *and* $A_{23}(L) \neq 0$;

H2: *"Stock" channel:* $A_{13}(L) \neq 0$, $A_{21}(L) \neq 0$, *and* $A_{23}(L) \neq 0$; *and*

H3: *"Flow" and "Stock" channels:* $A_{12}(L) \neq 0$, $A_{13}(L) \neq 0$, $A_{21}(L) \neq 0$, *and* $A_{23}(L) \neq 0$

Hypotheses

The following null hypotheses will be tested to examine the cointegration between FX markets and stock markets

H01: *no integration between variables (r=0), alternative hypothesis will be there is 1 or more co-integration vector (r>0). We calculate* λ_{trace} *(0), and*

H02: *there is 1 or less than 1 co-integration vector (*$0 \leq r \leq 1$*), against the alternative of 2 co-integration vectors.*

H03: *there are 2 or less than 2 co-integration vectors (*$1 \leq r \leq 2$*), against the alternative of 3 more than 3 co-integration vectors.*

The following three hypotheses will be also tested for the multivariate Granger causality:

H01: *"Flow" channel:* $A_{12}(L) = 0$, $A_{13}(L) = 0$, *and* $A_{23}(L) = 0$;

H02: *"Stock" channel:* $A_{13}(L) = 0$, $A_{21}(L) = 0$, *and* $A_{23}(L) = 0$; *and*

H03: *"Flow" and "Stock" channels:* $A_{12}(L) = 0$, $A_{13}(L) = 0$, $A_{21}(L) = 0$, *and* $A_{23}(L) = 0$

3.2 Data

Three Asian countries taken into empirical test along with the US are Japan, South Korea and Singapore. All the observations in this test are obtained from the International Financial Statistics database on International Monetary Fund (IMF) database website. The sample period of time is selected from January 1994 until February 2009 (except South Korea until March 2009) for all these countries. The data consists of monthly stock market index prices expressed in local currency; local bilateral spot exchange rates expressed as domestic currency per U.S dollar, and consumer price index (CPI). The real exchange rate is defined as

$$S_t = e_t \frac{CPI_t^{US}}{CPI_t} \quad (6)$$

where:

- CPI_t is the consumer price index for the Japan, South Korea and Singapore (domestic country).
- CPI_t^{US} is the consumer price index for the US.
- e_t is the nominal exchange rate (domestic currency/ US dollar).

This paper aims to investigate the dependence structure between stock exchange markets and foreign exchange markets during the financial crisis which affects Japan, Korea and Singapore fully or partially. Therefore, the sample period is aimed to divide into 4 different period of time, which includes:

Period 1-Before Asian Financial Crisis 1997 (January 1994 – June1997); Period 2-During Asian Financial Crisis (July 1997 – July 1999); Period 3-After Asian Financial Crisis and before Global Financial Crisis (August 1999 – June 2007); Period 4-During Global Financial Crisis (July 2007 – February 2009, except South Korea until March 2009).

4. Empirical Results

4.1 OLS regression result

Table 1 reports the OLS regression result. There are positive relationship between foreign exchange and stock markets for Japan, South Korea and Singapore. The results also show that the US stock price index does affect the domestic stock prices.

Table 1. Coefficient of $P_t^{domestic} = a_0 + a_1 S_t + a_2 P_t^{US} + \varepsilon_t$

	α_0	α_1	α_2	R-square	Adjusted R-square	P-value (F-statistic)
Japan	6.591 (13.302*)	0.620 (4.516*)	0.189 (3.023*)	0.103	0.093	0.000
Korea	15.639 (18.006*)	1.901 (13.873*)	0.557 (8.657*)	0.527	0.522	0.000
Singapore	2.802 (11.811*)	1.093 (5.619*)	0.542 (7.815*)	0.255	0.246	0.000

Figures in parentheses are t-statistic, * denotes significant at 5% level

We then test the null hypothesis to see if there is any relationship between change in FX rate or the US stock price and domestic stock price basing on the significant level at 5% by using t-statistic.

H_0: $\alpha_1 = 0$, $\alpha_2 = 0$; H_1: $\alpha_1 \neq 0$; $\alpha_2 \neq 0$

The results are also interesting. In all cases, the results suggest that we must reject the null hypothesis which is said that the US stock price does not affect these countries' stock price. Hence, it is said that the coefficient of the US stock market is significant in the case of Japan, Singapore, and South Korea. On the other hand, the foreign exchange rate also significant influence on domestic stock price in Japan and Singapore, and South Korea.

From the result summary, the unadjusted and adjusted coefficients of determination (R^2 and adjusted R^2) are high for South Korea, whereas they are lower in Japan and Singapore. They suggest that about 53% (South Korea) of the total variation in domestic stock prices can be explained by the variations in percentage changes in foreign exchange and the US stock price. On the other hand, there is just 10% and 25% of movement of variables can explain the change in Japanese and Singapore stock price, respectively. The results show that there is a high chance that South Korea stock market is explained by the other explanatory variable such as South Korea FX market and US stock market.

The P value in summarized table indicates for significant F statistic. This paper is going to test the null hypothesis of R-square is equal to zero, which means

H_0: $R^2 = 0$; H_1: $R^2 \neq 0$

In three case of Japan, South Korea and Singapore, the Significance F (is equal to the P value in table 1) are very low, which are less than 5% (i.e less than 0.05), then we can reject the null hypothesis of $R^2 = 0$ and accept the alternative hypothesis of R^2 # 0. It means that R^2 is significantly different from zero at the 5% level of significant. Then, we can conclude in light of this finding that the independent variables of FX market and US stock market do have explanatory power to the domestic stock market.

Table 2 reports the OLS regression results for four sub-periodsThe regression results presented that US stock price and FX rate are significant in most of the case during the period 1, which is before the Asian Financial Crisis 1997. There is only the FX rate in case of Singapore expresses as non-significant to the domestic stock market. This implies that we

need to accept the null hypothesis that $\alpha_1 = 0$, keeping the other variables constant, leads to a conclusion that the FX rate did not affect the Singapore stock price during this period. Different from the results of Japan and South Korea, there is also a positive relationship between US stock markets and Singapore stock markets before the Asian Financial Crisis 1997. It can be said that any improvement in US equity markets, i.e stock markets can lead to a positive change in Singapore stock markets. Once the Asian Financial Crisis occurs in 1997, Singapore is one of the economies who is impacted much from this crisis because of a negative changes of US stock markets.

Table 2. Testing coefficient of $P_t^{domestic} = a_0 + a_1 S_t + a_2 P_t^{US} + \varepsilon_t$ by using OLS regression for different 4 periods of Japan, South Korea and Singapore

	α_0	α_1	α_2
JAPAN			
Before Crisis 1997	2.828	-0.664	-0.344
01/1994 – 06/1997	(5.718 *)	(-4.253 *)	(-3.905 *)
During Crisis 1997	6.366	0.326	-0.099
07/1997 – 07/1999	(3.622*)	(0.997)	(-0.634)
Between two Crises	-4.210	-0.577	1.332
08/1999 – 06/2007	(-7.302 *)	(-6.134 *)	(23.788 *)
During Crisis 2007	-4.585	-0.195	1.009
07/2007 – 02/2009	(-4.308 *)	(-2.823 *)	(7.216 *)
SOUTH KOREA			
Before Crisis 1997	14.259	1.168	-0.433
01/1994 – 06/1997	(8.186 *)	(4.424 *)	(-8.672 *)
During Crisis 1997	9.909	1.267	0.778
07/1997 – 07/1999	(3.333 *)	(3.586 *)	(2.067 *)
Between two Crises	19.634	2.294	0.271
08/1999 – 06/2007	(16.875 *)	(16.599 *)	(2.841 *)
During Crisis 2007	4.624	0.388	0.772
07/2007 – 03/2009	(2.627 *)	(2.285 *)	(5.646 *)
SINGAPORE			
Before Crisis 1997	3.898	-0.424	0.137
01/1994 – 06/1997	(18.819*)	(-1.476)	(3.135 *)
During Crisis 1997	-1.124	4.473	1.729
07/1997 – 07/1999	(-0.865)	(5.008 *)	(4.748 *)
Between two Crises	-0.167	-0.083	1.073

08/1999 – 06/2007	(-0.173 *)	(-0.118)	(7.476 *)
During Crisis 2007	-2.404	-0.528	1.580
07/2007 – 02/2009	(-6.670 *)	(-1.563)	(23.235 *)

Note: Figures in parentheses are t-statistic, * denotes significant at 5% level

During the 1997 Asian Financial Crisis, the empirical results show that the US stock market and FX market are not significant in case of Japan, but they do affect the South Korea and Singapore stock markets. During this time, South Korea and Singapore are considered as NICs (Newly Industrialized Country) in Asia. They have close economic relationship with US. Besides, Singapore is one of the countries which is affected directly from Asian Financial Crisis 1997, after Thailand, so the results indicated that a change of Singapore stock index (α_2=1.729) is more than the other two countries (-0.099 and 0.778 for Japan and South Korea, respectively) due to one unit change in the US stock price, keeping the other variables constant. As mentioned in section of selected country, the Asian Financial Crisis 1997 start with the depreciation of Thailand currency (Baht Thai) and has strong impact in most of the South East Asia countries during this period, including Singapore. So this is the reason why Singapore stock markets fluctuated more than the other two countries when there are any changes in US stock markets, keeping FX rate unchanged.

After being affected from the Asian Financial Crisis 1997, these three countries executed reforms to strengthen their economies. However, the FX market and US stock markets still affect the domestic stock market in most cases at the level of significant of 5%. There are positive relationship between the US stock prices and domestic stock prices in all three cases of Japan, South Korea and Singapore. This implies that once there are any increases in the US stock markets, it can lead to the change in domestic stock markets toward the same direction. As mentioned above, the global financial crisis occurred since mid 2007, and peak of 2008, which initially started in the US, has impacted the rest of the world. Hence, the results show that the domestic stock price depends much on the US stock index during this period of global financial crisis.

4.2 Cointegration results

We test the cointegration between variables across three countries during four sub-periods between 1994 and 2009. The Johansen test is applied for this section to investigate how many cointegrating vectors which is expressed in *Equation 2*.

Firstly, this paper tests the unit roots test by using Augmented Dickey – Fuller (ADF) tests for stationary in the level of the series and the first difference of the series (P, S, and P_{US}). The hypothesis that the level of this series has a unit root can be accepted (cannot be rejected) in all cases and the hypothesis that the first difference of the series has a unit root can be rejected. So the results show that the time series are an I(1) variables (this results are presented in Table 3, can be available by using eViews).

After testing the unit root of the series, the cointegration is investigated by using the Johansen tests. This test investigates the null hypothesis of cointegration vectors r in *Equation 3* to see if there is any co-integration vector in this model. The following null hypotheses are tested and the results are shown in Table 4

H_{01}: *there is no integration between variables (r=0),*

H_{02}: *there is 1 or less than 1 co-integration vector (*$r \leq 1$*),*

H_{03}: *there is 2 or less than 2 co-integration vector (*$r \leq 2$*),*

The results of cointegration relationship between variables are shown in Table 4. The null hypothesis H_{01} which states that there is no cointegration vector cannot be rejected in the second and third sub-period across three countries.

Table 3. ADF Unit Root Tests

Augmented Dickey – Fuller (ADF) Unit Roots Tests				
Variables	***Period 1***	***Period 2***	***Period 3***	***Period 4***
P_Japan	-2.06	-1.91	-0.81	-0.33
P_Korea	-1.12	-1.36	-0.30	-0.69
P_Sing	-2.97	-0.99	-0.23	-0.59
P_US	1.53	-0.25	-0.91	0.54
Real_fx_japan	-0.72	-1.98	-0.76	-1.60
Real_fx_korea	-0.39	-2.16	-0.33	-0.59
Real_fx_sing	-3.27	-2.59	-2.65	-2.31
First difference				
rP_Japan	-4.58***	-3.13**	-7.34***	-3.99***
rP_Korea	-5.04***	-2.80*	-7.44***	-3.26**
rP_Sing	-7.21***	-4.34***	-9.53***	-3.36**
rP_US	-5.57***	-3.78***	-8.22***	-3.33**
rReal_fx_japan	-5.11***	-5.11***	-9.01***	-2.93*
rReal_fx_korea	-5.77***	-4.52***	-8.78***	-5.61***
rReal_fx_sing	-4.47***	-5.01***	-9.74***	-4.03***

*, **, and *** denote significant level of 10%, 5% and 1%, respectively

Table 4. Cointegration tests of $P_t^{domestic} = a_0 + a_1 S_t + a_2 P_t^{US} + \varepsilon_t$ Johansen tests statistics

	H_0: r = 0	**H_0: $r \leq 1$**	**H_0: $r \leq 2$**
JAPAN			
Jan 1994 – Jun 1997	20.74	7.36	0.46
Jul 1997 – Jul 1999	22.52	9.03	2.17
Aug 1999 – Jun 2007	19.62	3.25	0.03
Jul 2007 – Feb 2009	34.71**	9.41	0.32
SOUTH KOREA			
Jan 1994 – Jun 1997	33.98**	11.60	0.03
Jul 1997 – Jul 1999	16.25	5.95	0.04
Aug 1999 – Jun 2007	25.68	10.74	1.10
Jul 2007 – Mar 2009	36.43**	11.26	1.88

SINGAPORE			
Jan 1994 – Jun 1997	27.98*	9.45	0.01
Jul 1997 – Jul 1999	16.48	4.19	0.01
Aug 1999 – Jun 2007	24.97	7.02	0.03
Jul 2007 – Feb 2009	27.92*	9.72	0.50

Note: Figures are trace statistics, the r denotes the number of significant vectors, and the Johansen trace statistics test the hypothesis of at most two, one and zero cointegration vectors, respectively. ***, ** and * denote significance at 1%, 5% and 10% level, respectively. The period 1 (pre-Asian financial crisis 1997) indicates from Jan 1994 to Jun 1997, period 2 (during Asian financial crisis 1997) is from Jul 1997 to Jul 1999, period 3 is from Aug 1999 to Jun 2007, the last period (during current global crisis) indicates from Jul 2007 to Feb 2009 (except South Korea is to Mar 2009)

The null hypothesis is also accepted in the first sub-period, which is period of pre-Asian crisis 1997 in Japan. In South Korea and Singapore, we can reject the null hypothesis that there is zero cointegration vector between domestic stock price, the US stock price and FX rate during the pre-Asian crisis (except Japan) and the current global crisis 2007 at a 5% and 10% significance level.

In addition, the second and the third null hypothesis, H_{02} and H_{03}, respectively in the model cannot be rejected for all cases in the time series. This means that there is at least one cointegration vector which can show the links or the integrated relationship between stock markets and FX markets, especially during the global current crisis in all three countries. The current global financial crisis as mentioned in section *4.1* has impacted on Japan, South Korea and Singapore; hence these results can be evidences to show that there are some links between these markets due to cointegration vectors.

Cases of South Korea and Singapore are same when there are rejections of the first null hypotheses for same two periods, whenever we accepted both second and third null hypotheses during four periods of time. So, since South Korea and Singapore are New Industrialized Countries (NICs), it's necessary if their markets including stock markets and FX markets are connected to the US markets, to strengthen their economies. This also implies the linkage between the stock markets and FX markets, especially the relationship between the US and these countries. The trading issues in terms of exports and imports can be a measurement for the level of integration of a country. The results in this section can confirm the fact there is bilateral relationship between the US and domestic markets.

4.3 Multivariate Granger Causality Tests

In this section, we test the hypothesis regarding to two channels, "stock" and "flow" suggested by Phylaktis and Ravazzolo (2005). These hypotheses are investigated by testing the coefficient restrictions which are mentioned in section 3. According to that, this paper examine the null hypothesis of

H_{01}: *"Flow" channel:* $A_{12}(L)=0$, $A_{13}(L)=0$, *and* $A_{23}(L)=0$;

H_{02}: *"Stock" channel:* $A_{13}(L)=0$, $A_{21}(L)=0$, *and* $A_{23}(L)=0$; *and*

H_{03}: *"Flow" and "Stock" channels:* $A_{12}(L)=0$, $A_{13}(L)=0$, $A_{21}(L)=0$, *and* $A_{23}(L)=0$

by using Wald test. Moreover, the coefficient between the US stock index and Asian Stock Index is also examined by testing $A_{31}(L)=0$.

The first step of this methodology is finding the appropriate lag structure by using Wald test. This paper testing the VAR(k) against a VAR(k+1) and applied Wald tests on the VAR(k) coefficient matrix. Phylaktis and Ravazzolo (2005) suggested in their paper using Wald tests with standard Chi-square distribution (χ^2) with (n-1) degree of freedom.

Table 5 presents the order of lag length chosen by AIC and SC criterion. The order of lag length selected based on Schwarz criterion is k=1 for all four periods of time across three countries. However, the order of lag length from Akaike criterion is various across three countries through four periods of time. Then this paper will examine the Granger causality using Wald test for both criteria.

Table 5. Order of lag length, chosen by AIC and SC criterion

VAR Lag Order Criteria	Period 1 01/1994 – 06/1997	Period 2 07/1997 – 07/1999	Period 3 08/1999 – 06/2007	Period 4 07/2007 – 03/2009
JAPAN				
AIC	Lag 1	Lag 2	Lag 2	Lag 2
SC	Lag 1	Lag 1	Lag 1	Lag 1
SOUTH KOREA				
AIC	Lag 2	Lag 2	Lag 3	Lag 1
SC	Lag 1	Lag 1	Lag 1	Lag 1
SINGPAORE				
AIC	Lag 1	Lag 1	Lag 2	Lag 1
SC	Lag 1	Lag 1	Lag 1	Lag 1

Note: AIC is Akaike information criterion. SC is Schwarz information criterion.

After deal with the data and coefficient matrices, the VAR(1) for Japan, South Korea and Singapore in 4 periods are examined.

Table 6. Multivariate Granger Causality test with VAR(1) – Schwarz Information Criterion

		$A_{12}(L)=0$	$A_{13}(L)=0$	$A_{21}(L)=0$	$A_{23}(L)=0$	$A_{31}(L)=0$
JAPAN						
Jan 1994 – Jun 1997	χ^2	0.36	0.09	3.39*	12.90***	1.91
P value	(0.55)	(0.76)	(0.07)	(0.00)	(0.18)	
Jul 1997 – Jul 1999	χ^2	3.32*	4.83**	0.12	0.12	4.96**
P value	(0.08)	(0.04)	(0.73)	(0.73)		(0.03)
Aug 1999 – Jun 2007	χ^2	3.01*	1.71	0.56	1.30	2.71
P value	(0.09)	(0.19)	(0.45)	(0.25)		(0.10)
Jul 2007 – Feb 2009	χ^2	2.45	0.01	2.27	0.04	3.95*
P value	(0.13)	(0.91)	(0.15)	(0.85)		(0.06)
SOUTH KOREA						
Jan 1994 – Jun 1997	χ^2	0.35	3.41*	0.46	5.87**	1.37
P value	(0.56)	(0.07)	(0.50)	(0.02)	(0.25)	

Jul 1997 – Jul 1999	χ^2	1.27	2.71	0.24	0.22	2.16
P value	(0.27)	(0.11)	(0.62)	(0.64)	(0.16)	
Aug 1999 – Jun 2007	χ^2	0.02	2.36	16.61***	4.93**	0.00
P value	(0.89)	(0.13)	(0.00)	(0.03)	(0.98)	
Jul 2007 – Mar 2009	χ^2	6.60**	2.35	2.29	0.74	0.27
P value	(0.02)	(0.14)	(0.15)	(0.40)	(0.61)	
SINGAPORE						
Jan 1994 – Jun 1997	χ^2	0.02	1.95	1.74	2.03	0.93
P value	(0.87)	(0.17)	(0.19)	(0.16)	(0.34)	
Jul 1997 – Jul 1999	χ^2	1.81	0.39	1.08	4.79**	0.63
P value	(0.19)	(0.54)	(0.31)	(0.04)	(0.47)	
Aug 1999 – Jun 2007	χ^2	1.10	0.07	1.41	0.23	4.14**
P value	(0.29)	(0.79)	(0.24)	(0.63)	(0.04)	
Jul 2007 – Feb 2009	χ^2	2.47	0.76	0.03	0.00	36.99***
P value	(0.11)	(0.38)	(0.86)	(0.96)	(0.00)	

Note: Performing Multivariate Granger Tests by using Wald tests to examine the coefficient restrictions with chi-square distribution (χ^2). Figures in parentheses are P value; ***, ** and * denote significance at level of 1%, 5% and 10% respectively. The period 1 (pre-Asian financial crisis 1997) indicates from Jan 1994 to Jun 1997, period 2 (during Asian financial crisis 1997) is from Jul 1997 to Jul 1999, period 3 is from Aug 1999 to Jun 2007, the last period (during current global crisis) indicates from Jul 2007 to Feb 2009 (except South Korea is to Mar 2009).

This paper investigates the Granger causality test through the flow and stock channel by testing the restrictions which is followed by Wald test. The "flow" channel is examined with the restrictions of A_{12}, A_{13}, and A_{23}. The restrictions of A_{13}, A_{21}, and A_{23} are used for testing the 'stock' channel. Moreover, the restriction of A_{31} is referred as the impact or causality of domestic stock markets across Japan, South Korea and Singapore to the US stock markets. The results which are generated by eViews are presented in Table 6.

Firstly, this paper analyses the relationship between restrictions of A_{13} and A_{31}. As the results in Table 6, at the significant level of 5% and 10%, the restriction of A_{13} is rejected in some periods of Japan and South Korea, whereas the restriction of A_{31} is accepted in all of four periods in South Korea and first two periods of Singapore. If the significant level of 25% is counted in this analysis, the number of periods in which the restriction of A_{13} is rejected increase. It includes period 2 and 3 in Japan, all four periods in South Korea, and the first period in Singapore. Generally, that the restriction A_{13} is rejected and A_{31} is accepted at the same time occurs during four periods of time since 1994 until first quarter of 2009 in South Korea (at up to 25% of significant level) and before the Asian financial Crisis 1997 in Singapore. This relationship implies that the US stock markets do impact and cause the change in domestic stock markets in South Korea and Singapore. This result proves the strong link between the US economy and these Asian economies, especially in South Korea since 1994 until now during the Asian financial Crisis 1997 and the current global financial crisis 2007, 2008.

Secondly, the flow scenario which is introduced in section 3.1.2 is presented in this section by looking at the restrictions of A_{12}, A_{13} and A_{23}. According to Granger causality ideas, this scenario shows the relationship of the FX markets and stock markets (of the US as well as domestic ones). There is no case that shows the flow channel since those restrictions cannot be rejected at the same time in all cases across these three countries. There are some cases that imply

the link between the domestic stock markets - the FX markets, and the domestic ones with the US stock markets. These issues occur during the period of crisis 1997 in Japan and current global crisis 2008 in South Korea since the restrictions of $A_{12}=0$ and $A_{21}=0$ are rejected. However, the stock channel is adopted by South Korea and Singapore since the restrictions $A_{13}=0$, $A_{21}=0$ and $A_{23}=0$ are all rejected for the time pre-global crisis and during global crisis 2007, 2008 (South Korea) and pre-Asian financial crisis 1997 (in Singapore). Hence, since the years after Asian Financial Crisis, South Korea markets started to connect through stock channel, while the Singapore markets have connected since the early of 1990s, before the Asian crisis. This channel also proves the evidence that there is a strong link from the FX markets, which depend much on the relative strength of the various in pre-crisis. Whatever changes in stock markets at that time will cause the fluctuation in the FX rates and can be a reason leads to the crisis then.

The order of lag structure is chosen by Akaike Information Criterion is various between four periods of time across three countries. Table 7 presents the results of Granger causality which is investigate by using Wald test.

Table 7. Multivariate Granger Causality test with VAR(k) – Akaike information criterion

		$A_{12}(L)=0$	$A_{13}(L)=0$	$A_{21}(L)=0$	$A_{23}(L)=0$	$A_{31}(L)=0$
JAPAN						
Jan 1994 – Jun 1997	χ^2	0.36	0.09	3.39*	12.90***	1.91
P value		(0.55)	(0.76)	(0.07)	(0.00)	(0.18)
Jul 1997 – Jul 1999	χ^2	5.51*	3.97	0.85	1.64	3.89
P value		(0.06)	(0.14)	(0.65)	(0.44)	(0.14)
Aug 1999 – Jun 2007	χ^2	3.20	1.63	1.48	1.81	5.41*
P value		(0.20)	(0.44)	(0.48)	(0.40)	(0.07)
Jul 2007 – Feb 2009	χ^2	4.87*	1.77	8.85**	2.00	10.88***
P value		(0.08)	(0.41)	(0.01)	(0.37)	(0.00)
SOUTH KOREA						
Jan 1994 – Jun 1997	χ^2	3.92	9.3**	0.75	4.60	2.60
P value		(0.14)	(0.01)	(0.69)	(0.10)	(0.27)
Jul 1997 – Jul 1999	χ^2	6.23**	1.92	0.26	0.77	290.61***
P value		(0.04)	(0.38)	(0.88)	(0.68)	(0.00)
Aug 1999 – Jun 2007	χ^2	16.01***	4.50	14.86***	6.42*	0.74
P value		(0.00)	(0.21)	(0.00)	(0.09)	(0.86)
Jul 2007 – Mar 2009	χ^2	6.60**	2.35	2.29	0.74	0.27
P value		(0.02)	(0.14)	(0.15)	(0.40)	(0.61)
SINGAPORE						
Jan 1994 – Jun 1997	χ^2	0.02	1.95	1.74	2.03	0.93

P value		(0.87)	(0.17)	(0.19)	(0.16)	(0.34)
Jul 1997 – Jul 1999	χ^2	1.81	0.39	1.08	4.79**	0.63
P value		(0.19)	(0.54)	(0.31)	(0.04)	(0.47)
Aug 1999 – Jun 2007	χ^2	8.74**	5.99*	0.99	1.36	6.37**
P value		(0.01)	(0.05)	(0.61)	(0.51)	(0.04)
Jul 2007 – Feb 2009	χ^2	2.47	0.76	0.03	0.00	36.99***
P value		(0.11)	(0.38)	(0.86)	(0.96)	(0.00)

Note: Performing Multivariate Granger Tests by using Wald tests to examine the coefficient restrictions with chi-square distribution (χ^2). Figures in parentheses are P value; ***, ** and * denote significance at level of 1%, 5% and 10% respectively. The period 1 (pre-Asian financial crisis 1997) indicates from Jan 1994 to Jun 1997, period 2 (during Asian financial crisis 1997) is from Jul 1997 to Jul 1999, period 3 is from Aug 1999 to Jun 2007, the last period (during current global crisis) indicates from Jul 2007 to Feb 2009 (except South Korea is to Mar 2009)

The results based on Akaike Information Criterion are significantly different from the one follows to the Schwarz criterion due to the different VAR lag order. The results in Table 6 show that the South Korea markets did connected through flow channel during sub period 1 and 3, which are pre-crises period in 1997 and 2007 since the null hypothesis H_{01}: $A_{12}=0$, $A_{13}=0$ *and* $A_{23}=0$ is rejected. Besides, the results also show that Japan and Singapore markets did not connected through flow channel.

The results also further show the link of the stock channel within markets of each country. The result also shows that the null hypothesis H_{02}: $A_{13}=0$, $A_{21}=0$ *and* $A_{23}=0$ is rejected in some cases. In Singapore, the markets seem to be connected through stock channel in the pre-Asian crisis 1997, since January 1994 until the Asian financial crisis 1997. The South Korea markets also connected through stock channel in the pre-global crisis. These results are same with the one in the sub-section *5.3.1*. The only different issue from the previous sub-section is that the South Korea markets did connect through both flow and stock channel since all the restrictions A_{12}, A_{13}, A_{21} and A_{23} are statistically different from zero. The exchange rate play an important role in making balance the domestic demand and supply of the assets in economy, which helps to improve the strength of the economy as well as improve the domestic stock price. On the other hands, a balance and development in domestic demand and supply leads to the demand for foreign security and follows by the appreciation in exchange rate.

5. Policy Implications

The empirical results in *section 4* show that impacts on Japan during two crises in 1990s and 2000s. Following the fluctuation in domestic stock markets after the Asian financial crisis 1997 and the recession in Japan in 1990s, the Japanese government started to design and execute a new monetary policy which can bring benefits to its economies at that time. The quantitative monetary easing was implemented by Bank of Japan since March 2001 and is one of policies of recovering Japanese economies after recession and crisis. The main issue of quantitative easing policy is that the interest rate is close to zero. This leads to the changes in stock prices and the impacts of the FX rate on stock prices due to the application of this policy. One of the purposes of implementing this policy is recovering the Japanese economies. On the other hand, this policy also influenced stock markets, i.e the stock prices increased after crisis (Kurihara, 2006). Besides, the policy also keeps exchange rate and US stock price as a main target which impact on the domestic stock markets. Kurihara (2006) also has conclusions of the effectiveness from the Japanese quantitative easing policy. He concludes that easing policy since March, 2001 is applied effectively in impacting the domestic stock prices. In addition, the VAR (vector autoregression) models from this expansion policy have a positive effect on Japanese stock prices, investment as well as production (Kirchner, 2006; Zammit, 2006). Kirchner also finds that there are reliable supports for an effect from quantitative easing measures on bond yields as well as domestic stock prices in Japan. In brief, the Japanese quantitative monetary easing is one of implications of

Japan government in case of promoting the recovery its economy, including stock and FX markets.

Similar to Japan, South Korea government also published policies to rescue the economy after crisis. Kim and Rhee (2009) show that main reasons for the current global financial crisis are the boom of the real estate markets bubble and a fall down of financial system in South Korea. So it is necessary for the central bank in South Korea to monitor the real estate, stock and derivative markets. Moreover, it provides the liquidity for financial structure but reorganises to respond to the crisis effectively. After all impacts that South Korea is suffered, the government has to follow some restructure in the purpose of saving the economy out of the crisis. As the results of that, the financial restructure and corporate restructure need to be done at the same time to strengthen the financial systems in South Korea. If the Japanese government uses the quantitative monetary easing to recover its economy, hence it's not the case in South Korea. The monetary easing policy is not work properly and effectively in case of South Korea. Instead of that, the fiscal policy was implemented to seek for a balance between banking sectors and capital markets (Park and Lee, 2009).

The policies and strategies in Singapore also need to be mentioned as an implication of the Singapore's government after the crises. Because during the period of crisis, most entrepreneurs in Singapore have to face with uncertainty hardship and depression, results in an economic downturn in Singapore's economy. Hence, it is significant for the government to look at its economy and execute the appropriate policies to strengthen the financial markets. Due to experience in previous financial crisis, the Monetary Authority of Singapore has been maintaining the strong financial system to ensure well functioning markets. In addition, the confidence of investor needs to be kept by any incentive strategies from the government. As a result of that, Singapore government has implemented the current monetary policy which can support price stability through Singapore exchange markets (Keat, 2009). Besides, Singapore also sets stringent criteria for equity markets, i.e stock markets in order to create more transparency in financial markets after crises.

6. Conclusion

In this paper, we examine the dependence structure between equity and foreign exchange markets in three industrial Asian countries including Japan, South Korea and Singapore. The empirical results provide some insights on the relationship between equity and FX markets. First, between 1994 and 2009, the general investigation on coefficients of the model presents the positive relationship of between domestic stock price and foreign exchange rate, as well as the US stock price index in all cases across countries. The regression on four sub-periods also implies the positive relationship between stock markets and FX markets for some cases. In Singapore, the impact of the FX markets and the US stock markets is stronger during the Asian financial crisis 1997, in comparison to the other periods due to high coefficient α_1 and α_2 **(**in absolute value). This regression shows that the US stock market is an important independent variable, along with the FX market; both of them also have a strong link with the domestic stock markets.

Second, the cointegration investigation by using Johansen trace test also shows the connection between markets across these three countries. Although there are some rejections of the null hypotheses before the Asian Financial Crisis 1997 and during the current Global Financial Crisis 2007 - 2008, the other cases are all accepted even for both the hypotheses at most two or one cointegration vectors. The results from this test can confirm the relationship between the US and each domestic market through the existence of cointegration vectors.

Third, the multivariate Granger causality tests also further presented the link between FX and domestic stock markets. Under Schwarz Information Criterion, the results show the causality between the US stock markets and the domestic ones in some cases of South Korea and Singapore. There are connections between markets in South Korea and Singapore through stock channel during the global current crisis, but no case implies the flow connection under this criterion. However, it is not the case under the Akaike Information Criterion when South Korea markets did connect through flow channel. Moreover, South Korea markets are also linked together through both "flow" and "stock" channel during the global current crisis in 2007 - 2008 under this criterion. The results indicated that the exchange rate determinant dose not only depend on economic activities but also the strength and wealth of those activities. The exchange rate plays an important role in making balance the domestic demand and supply of the assets in economy, which helps to improve the strength of the economy as well as the domestic stock price. On

the other hand, a balance and development in domestic demand and supply leads to the demand for foreign security and follows by the appreciation in exchange rate.

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Minimax Theorem and Nash Equilibrium

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***Abstract*— Two important results in Economics, the Minimax Theorem and the Nash Equilibrium are presented together with their mathematical fundaments. The results are obtained in the field of Functional Analysis.**

***Keywords*—** *Minimax Theorem, Nash Equilibrium.*

1. Introduction

In this work it will be seen as the convex sets strict separation result allows obtaining a fundamental result in Game Theory: The Minimax Theorem. The mathematical structure considered is the real Hilbert spaces, see Ferreira *et. al* (2010).

Then the same will be done for Nash Equilibrium using mainly Kakutani's Theorem, see Kakutani (1941), Matos and Ferreira (2006) and Ferreira *et. al* (2010).

2. Minimax Theorem

The context considered is the one of the Games of two players with null sum:

- Be $\Phi(\boldsymbol{x},\boldsymbol{y})$ a two variables real function, $\boldsymbol{x},\boldsymbol{y} \in H$, being H a real Hilbert space.
- Be A and B two convex sets in H.
- One of the players chooses strategies (points) in A in order to maximize $\Phi(\boldsymbol{x},\boldsymbol{y})$ (or minimize $-\Phi(\boldsymbol{x},\boldsymbol{y})$): it is a maximizing player.
- The other player chooses strategies (points) in B in order to minimize $\Phi(\boldsymbol{x},\boldsymbol{y})$ (or maximize $-\Phi(\boldsymbol{x},\boldsymbol{y})$): it is the minimizing player.

The function $\Phi(\boldsymbol{x},\boldsymbol{y})$ is the *payoff function*. $\Phi(\boldsymbol{x}_0,\boldsymbol{y}_0)$ represents, simultaneously, the maximizing player gain and the minimizing player loss in a move where they choose, respectively, the strategies $\boldsymbol{x}_0$ and $\boldsymbol{y}_0$. So the gain of one of the players is identical to the loss of the other. Because of it the game is said of null sum.

In these conditions the game has value C if

$$\sup_{\boldsymbol{x}\in A}\inf_{\boldsymbol{y}\in B}\Phi(\boldsymbol{x},\boldsymbol{y}) = C = \inf_{\boldsymbol{y}\in B}\sup_{\boldsymbol{x}\in A}\Phi(\boldsymbol{x},\boldsymbol{y}). \quad (2.1)$$

If, for any $(\boldsymbol{x}_0,\boldsymbol{y}_0), \Phi(\boldsymbol{x}_0,\boldsymbol{y}_0) = C$, $(\boldsymbol{x}_0,\boldsymbol{y}_0)$ is said to be a pair of *optimal strategies*. It will be also a saddle point if it verifies in addition

$$\Phi(\boldsymbol{x},\boldsymbol{y}_0) \le \Phi(\boldsymbol{x}_0,\boldsymbol{y}_0) \le \Phi(\boldsymbol{x}_0,\boldsymbol{y}), \boldsymbol{x} \in A, \boldsymbol{y} \in B. \quad (2.2)$$

It is conceptually easy to generalize this situation to a n players null sum game, although algebraically fastidious.

The fundamental result in this section is:

Theorem 2.1 (Minimax Theorem)

A and B are closed convex sets in H and A also limited. $\Phi(\boldsymbol{x},\boldsymbol{y})$ is a real function defined for $\boldsymbol{x}$ in A and $\boldsymbol{y}$ in B such that:

- $\Phi(\boldsymbol{x},(1-\theta)\boldsymbol{y}_1+\theta\boldsymbol{y}_2)\leq(1-\theta)\Phi(\boldsymbol{x},\boldsymbol{y}_1)+\theta\Phi(\boldsymbol{x},\boldsymbol{y}_2)$ for $\boldsymbol{x}$ in A and $\boldsymbol{y}_1,\boldsymbol{y}_2$ in B, $0\leq\theta\leq1$ (that is: $\Phi(\boldsymbol{x},\boldsymbol{y})$ is convex in $\boldsymbol{y}$ for each $\boldsymbol{x}$),

- $\Phi\big((1-\theta)\boldsymbol{x}_1+\theta\boldsymbol{x}_2,\boldsymbol{y}\big)\geq(1-\theta)\Phi(\boldsymbol{x}_1,\boldsymbol{y})+\theta\Phi(\boldsymbol{x}_2,\boldsymbol{y})$ for $\boldsymbol{y}$ in B and $\boldsymbol{x}_1,\boldsymbol{x}_2$ in A, $0\leq\theta\leq1$ (that is: $\Phi(\boldsymbol{x},\boldsymbol{y})$ is concave in $\boldsymbol{x}$ for each $\boldsymbol{y}$),

- $\Phi(\boldsymbol{x},\boldsymbol{y})$ is continuous in $\boldsymbol{x}$ for each $\boldsymbol{y}$.

So (2.1) holds, that is the game has a value.

Demonstration:

Beginning by the most trivial part of the demonstration:

$$\inf_{\boldsymbol{y}\in B}\Phi(\boldsymbol{x},\boldsymbol{y})\leq\Phi(\boldsymbol{x},\boldsymbol{y})\leq\sup_{\boldsymbol{x}\in A}\Phi(\boldsymbol{x},\boldsymbol{y})$$

and so

$$\sup_{\boldsymbol{x}\in A}\inf_{\boldsymbol{y}\in B}\Phi(\boldsymbol{x},\boldsymbol{y})\leq\inf_{\boldsymbol{y}\in B}\sup_{\boldsymbol{x}\in A}\Phi(\boldsymbol{x},\boldsymbol{y}).$$

Then, as $\Phi(\boldsymbol{x},\boldsymbol{y})$ is concave and continuous in $\boldsymbol{x}\in A$, A convex, closed and limited, it follows that $\sup_{x\in A}\Phi(\boldsymbol{x},\boldsymbol{y})<\infty$.

Be $C=\inf_{\boldsymbol{y}\in B}\sup_{\boldsymbol{x}\in A}\Phi(\boldsymbol{x},\boldsymbol{y})$.

Suppose now that there is $\boldsymbol{x}_0\in A$ such that $\Phi(\boldsymbol{x}_0,\boldsymbol{y})\geq C$, for any $\boldsymbol{y}$ in B. In this case, $\inf_{\boldsymbol{y}\in B}\Phi(\boldsymbol{x}_0,\boldsymbol{y})\geq C$ or $\sup_{\boldsymbol{x}\in A}\inf_{\boldsymbol{y}\in B}\Phi(\boldsymbol{x},\boldsymbol{y})\geq C$ as it is convenient. Then the existence of such a $\boldsymbol{x}_0$ will be proved.

For any $\boldsymbol{y}$ in B, be $A_{\boldsymbol{y}}=\{\boldsymbol{x}\in A:\Phi(\boldsymbol{x},\boldsymbol{y})\geq C\}$.
$A_{\boldsymbol{y}}$ is closed, limited and convex. Suppose that, for a finite set $(\boldsymbol{y}_1,\boldsymbol{y}_2,\dots,\boldsymbol{y}_n)$, $\bigcap_{i=1}^{n}A_{\boldsymbol{y}_i}=\emptyset$. Consider the transformation from A to E_n defined by

$$f(\boldsymbol{x})=(\Phi(\boldsymbol{x},\boldsymbol{y}_1)-C,\Phi(\boldsymbol{x},\boldsymbol{y}_2)-C,\dots,\Phi(\boldsymbol{x},\boldsymbol{y}_n)-C).$$

Call G the $f(A)$ convex hull closure. Be P the E_n closed positive cone. Now it is shown $P\bigcap G=\emptyset$: in fact, being $\Phi(\boldsymbol{x},\boldsymbol{y})$ concave in $\boldsymbol{x}$, for any $\boldsymbol{x}_k$ in A, $k=1,2,\dots,n$, $0\leq\theta_k\leq1$, $\sum_{k=1}^{n}\theta_k=1$,

$$\sum_{k=1}^{n}\theta_k(\Phi(\boldsymbol{x}_k,\boldsymbol{y})-C)\leq\Phi\left(\sum_{k=1}^{n}\theta_k\boldsymbol{x}_k,\boldsymbol{y}\right)-C$$

and so the convex extension of $f(A)$ does not intersect P.

Consider now a sequence $\boldsymbol{x}_n$ of elements of A, such that $f(\boldsymbol{x}_n)$ converges for $\boldsymbol{v},\boldsymbol{v}\in E_n$. As A is closed, limited and convex, it is possible to define a subsequence, designated $\boldsymbol{x}_m$ such that $\boldsymbol{x}_m$ converges weakly for an element of A (call it $\boldsymbol{x}_0$). And, for any $\boldsymbol{y}_i$ as $\Phi(\boldsymbol{x},\boldsymbol{y}_i)$ is concave in $\boldsymbol{x}$,

$$\overline{lim}\,\Phi(\boldsymbol{x}_m,\boldsymbol{y}_i)\leq\Phi(\boldsymbol{x}_0,\boldsymbol{y}_i),\text{ or }f(\boldsymbol{x}_0)\geq\overline{lim}f(\boldsymbol{x}_m=\boldsymbol{v}).$$

So $P\bigcap G=\emptyset$. Then, G and P may be strictly separated, and it is possible to find a vector in E_n with coordinates a_k, such that

$$\sup_{\boldsymbol{x}\in A}\sum_{i=1}^{n}a_i(\Phi(\boldsymbol{x},\boldsymbol{y}_i)-C)<\sum_{i=1}^{n}a_i\boldsymbol{e}_i,$$

with the whole a_i greater or equal than zero.

Obviously, the a_i cannot be simultaneously null. So dividing for $\sum_{i=1}^{n}a_i$ and taking in account the convexity of $\Phi(\boldsymbol{x},\boldsymbol{y})$ in $\boldsymbol{y}$

$$\sup_{\boldsymbol{x}\in A}\Phi(\boldsymbol{x},\overline{\boldsymbol{y}})-C<0,\text{where }\overline{\boldsymbol{y}}=\frac{\sum_{k=1}^{n}a_k\boldsymbol{y}_k}{\sum_{k=1}^{n}a_k}.$$

And, evidently, or $\overline{\boldsymbol{y}}\in B$ or $\inf_{\boldsymbol{y}\in B}\sup_{\boldsymbol{x}\in A}\Phi(\boldsymbol{x},\boldsymbol{y})<C$. This contradicts the definition of C. So,

$$\bigcap_{i=1}^{n}A_{\boldsymbol{y}_i}\neq\emptyset.$$

In fact,

$$\bigcap_{\boldsymbol{y}\in B}A_{\boldsymbol{y}}\neq\emptyset$$

as it will be seen in the sequence using that result and proceeding by absurd. Note that $A_{\boldsymbol{y}}$ is a closed and convex set and so it is also weakly closed. And being bounded it is compact in the weak topology[1], as A. Calling $G_{\boldsymbol{y}}$ the complement of $A_{\boldsymbol{y}}$ it results that $G_{\boldsymbol{y}}$ is open in the weak topology. So, if

[1] See, for instance, Kantorovich and Akilov (1982).

$\bigcap_{y\in B} A_y$ is empty, $\bigcap_{y\in B} G_y \supset H \supset A$. But, being A compact, a finite number of G_{y_i} is enough to cover A:

$$\bigcup_{i=1}^{n} G_{y_i} \supset A;$$

that is: $\bigcap_{i=1}^{n} A_i$ is in the complement of A and so it must be $\bigcap_{i=1}^{n} A_{y_i} = \emptyset$, leading to a contradiction.

Suppose then that $\boldsymbol{x}_0 \in \bigcap_{y\in B} A_y$. So, in fact $\boldsymbol{x}_0$ satisfies $\Phi(\boldsymbol{x}_0, \boldsymbol{y}) \geq C$, as requested.

Then it follows a Corollary of Theorem 2.1, obtained strengthening its hypothesis.

Corollary 2.1

Suppose that the functional $\Phi(\boldsymbol{x}, \boldsymbol{y})$ defined in Theorem 2.1 is continuous in both variables, separately, and that B is also limited. So, there is an optimal pair of strategies, with the property of being a saddle point.

Demonstration:

It was already seen that exists $\boldsymbol{x}_0$ such that

$$\Phi(\boldsymbol{x}_0, \boldsymbol{y}) \geq C \qquad (2.3)$$

for each $\boldsymbol{y}$. As $\Phi(\boldsymbol{x}_0, \boldsymbol{y})$ is continuous in $\boldsymbol{y}$ and B is limited

$$\inf_{\boldsymbol{y}\in B} \Phi(\boldsymbol{x}_0, \boldsymbol{y}) = \Phi(\boldsymbol{x}_0, \boldsymbol{y}_0) \geq C \qquad (2.4)$$

for any $\boldsymbol{y}_0$ in B [2]. But $\inf_{\boldsymbol{y}\in B} \Phi(\boldsymbol{x}_0, \boldsymbol{y}) \leq \sup_{\boldsymbol{x}\in A} \inf_{\boldsymbol{y}\in B} \Phi(\boldsymbol{x}, \boldsymbol{y}) = C$ and, so

$$\Phi(\boldsymbol{x}_0, \boldsymbol{y}_0) = C. \qquad (2.5)$$

The saddle point property follows immediately from (2.3), (2.4) and (2.5)■.

3. Nash Equilibrium

The formulation and resolution of a game is very important in Game Theory. There are several game solution concepts. But some of these concepts are restrict to a certain kind of games. The most important solution concept was defined by John Nash (Nash, 1950). It will be seen that the Nash equilibrium existence is guaranteed for a large class of games.

E_n is the finite set of available strategies for a player. The Cartesian product of these sets is denoted by E. A typical element of this set is $\boldsymbol{e} = (e_1, e_2, \dots, e_N)$, called a pure strategy profile, where each e_n is a pure strategy for player n.

Definition 3.1

A mixed strategy of a player n is a lottery over the pure strategies of player n.

Observation:

- One of player n's mixed strategies is denoted σ_n and the set of all player n's mixed strategies is denoted Σ_n.
- Thus $\boldsymbol{\sigma}_n = \left(\sigma_n(e_n^1), \sigma_n(e_n^2), \dots, \sigma_n\left(e_n^{k_n}\right)\right)$ where k_n is the number of pure strategies of player n and $\sigma_n(e_n^i) \geq 0, i = 1, 2, \dots, k_n$ and $\sum_{i=1}^{k_n} \sigma_n(e_n^i) = 1$.
- The Cartesian product $\Sigma = \Sigma_1 \times \Sigma_2 \times \dots \times \Sigma_N$ is the set of all mixed strategy profiles.
- So, the mixed strategy set for each player is the probability distribution set over its pure strategy set.

Definition 3.2

A n-dimensional simplex defined by the $n+1$ points $\boldsymbol{x}_0, \boldsymbol{x}_1, \dots, \boldsymbol{x}_n$ in $\mathbb{R}^p, p \geq n$, is denoted $\langle \boldsymbol{x}_0, \boldsymbol{x}_1, \dots, \boldsymbol{x}_n \rangle$ and is defined by the set

$$\left\{ \mathbb{R}^p : \boldsymbol{x} = \sum_{j=0}^{n} \theta_j \boldsymbol{x}_j, \sum_{j=0}^{n} \theta_j = 1, \theta_j \geq 0 \right\}.$$

Observation:

- The simplex is non degenerate if the n vectors $\boldsymbol{x}_1 - \boldsymbol{x}_0, \dots, \boldsymbol{x}_n - \boldsymbol{x}_0$ are linearly independent.
- If $\boldsymbol{x} = \sum_{j=0}^{n} \theta_j \boldsymbol{x}_j$, the numbers $\theta_0, \theta_1, \dots, \theta_n$ are called the barycenter coordinates of $\boldsymbol{x}$.

[2] A continuous convex functional in a Hilbert space has minimum in any limited closed convex set.

- The barycentre of the simplex $\langle \boldsymbol{x}_0, \boldsymbol{x}_1, \dots, \boldsymbol{x}_n \rangle$ is the point having the whole barycenter coordinates equal to $(n+1)^{-1}$.

Definition 3.3

Call $u_n(\sigma)$ the expected payoff function of player n associated to the mixed strategy profile $\sigma = (\sigma_1, \sigma_2, \dots, \sigma_N)$.

Definition 3.4

A Nash equilibrium of a game is a profile of mixed strategies $\sigma = (\sigma_1, \sigma_2, \dots, \sigma_N)$ such that for each $n = 1, 2, \dots, N$ for each e_n and $e_n^{'}$ in E_n, if $\sigma_n(e_n) > 0$ then

$$u_n(\sigma_1, \sigma_2, \dots, \sigma_{n-1}, e_n, \sigma_{n+1}, \dots, \sigma_N) \geq u_n(\sigma_1, \sigma_2, \dots, \sigma_{n-1}, e_n^{'}, \sigma_{n+1}, \dots, \sigma_N).$$

Observation:

- So an equilibrium is a profile of mixed strategies such that a player knows what strategies the other players will go to choose, and no player has incentive to deviate from the equilibrium since that it cannot improve its payoff through an unilateral change of its strategy.

- A Nash equilibrium induces a necessary condition of strategic stability.

For the sequence it is necessary the following result:

Theorem 3.1 (Kakutani)

Let $M \subset \mathbb{R}^n$ be a compact convex set. Let $F \to\to M$ an upper hemi-continuous convex valued correspondence. Then the correspondence F has a fixed point.

Theorem 3.2 (Nash)

The mixed extension of every finite game has, at least, one strategic equilibrium.

Demonstration:

Consider the set-valued mapping that maps each strategy profile, $\boldsymbol{x}$, to all strategy profiles in which each player's component strategy is a best response to $\boldsymbol{x}$. That is, maximizes the player's payoff given that the others are adopting their components of $\boldsymbol{x}$. If a strategy profile is contained in the set to which it is mapped (is a fixed point) then it is an equilibrium. This is so because a strategic equilibrium is, in effect, defined as profile that is a best response it itself.

Thus the proof of existence of equilibrium amounts to a demonstration that the best response correspondence has a fixed point. The fixed – point theorem of Kakutani asserts the existence of a fixed point for every correspondence from a convex and compact subset of Euclidean space into itself, provided two conditions hold. One, the image of every set must be convex. And two, the graph of the correspondence (the set of pairs ($\boldsymbol{x}$,$\boldsymbol{y}$) where $\boldsymbol{y}$ is the image of $\boldsymbol{x}$) must be closed.

Now, in the mixed extension of a finite game, the strategies set of each player consists of all vectors (with as many components as there are pure strategies) of non negative numbers that sum to 1; that is, it is a simplex. Thus, the set of all strategy profiles is a product of simplexes. In particular, it is a convex and compact subset of Euclidean space. Given a particular choice of strategies by the other players, a player's best responses consist of all (mixed) strategies that put positive weight on those pure strategies that highest expected payoff among all the pure strategies. Thus, the set of best responses is a sub simplex. In particular, it is convex.

Finally, note that the conditions that must be met for a given strategy to be a best response to a given profile are all weak polynomial inequalities, so the graph of the best response correspondence is closed.

Thus, all the conditions of Kakutani's theorem hold, and this completes the proof of Theorem 3.2.

4. Conclusions

Minimax Theorem, see Neumann and Morgenstern (1947), and Nash Equilibrium, see Nash (1951), were two main achievements that give raise to a great spread of the Game Theory Applications namely in the Economic Domain.

Both concepts were not developed initially in a pure mathematical context. Only latter the problem of rigorous mathematic application to develop these results was considered. A simple and clear way to develop mathematically the Minimax Theorem may be seen in Brézis (1983). For the Nash Equilibrium see for instance Matos and Ferreira (2006) and Ferreira *et. al* (2010).

The due value in practical applications was recognized to Minimax Theorem first than to the Nash Equilibrium. This one had in recent times

finally the deserved recognition with the award of the Economics Nobel Prize.

It may be said that the Minimax Theorem is more considered in domains like Operations Research than in Economics. The opposite happens with the Nash Equilibrium. In particular in the famous Cournot-Nash Model, among others.

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Preference Portfolio of Small Investors With Reference To Mutual Funds

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Abstract **- A mutual fund is a single large professionally managed investment organization that gained a tremendous attention by the individual investors to satisfy their investment needs. The paper argues and supports the hypothesis stating that the small investor's perception towards the growth and success of mutual funds industry in India is positive. The survey was conducted in twin cities of Hyderabad and Secunderabad, State of Andhra Pradesh in India. It was concluded that the majority of the small investors are relatively young and equipped with high level education. They are all employed and belong to the range of up to 3 lac[1] income. The majority of the small investors preferred to invest in growth funds followed by open end funds, money market instruments, balanced funds and income funds in the order.**

Keywords - Mutual Fund, Professional Management, Gilt Funds, Growth Funds.

1. Introduction

Conceptually, a mutual fund is a single large professionally managed investment organization, that combines the money of many individual investors, having similar investments objectives. It invests this money in a wide variety of securities and individual investors share its income and expenses, its profits and losses, its capital appreciation and growth in proportion to their share holdings. In other words, a mutual fund is a type of investment institutions, which mobilizes savings of individuals and institutions and channelizes these savings' incorporate securities to provide investors a steady stream of returns and capital appreciation. Thus, the two prime advantages of investments in mutual funds of diversification and professional investment management become recognized by the investors.

1.1 Classification of mutual funds

Broadly, mutual funds can be classified into three categories:

1.1.1 Portfolio Classification of Mutual Funds

In this category, funds differ one from another with respect to the types of securities, which comprise the portfolio. Different funds are designed to cater to the risk and return profile of different types of investors. Thus, objectives of the funds differ significantly giving rise to (i) Growth funds, (ii) income funds, (iii) balanced funds, (iv) monthly income plans, (v) gilt funds, (vi) liquid/ money markets funds, (vii) index funds, (viii) sector funds, (ix) tax-saving funds, (x) systematic withdrawal plans and (xi) miscellaneous funds, as follows:

a) *Growth Funds*: The objective of a growth fund is to achieve long-term capital appreciation by predominantly investing in growth oriented equity shares of companies.
b) *Income Funds*: The focus of such funds is to generate a steady stream of income consistent with preservation of capital and liquidity.
c) *Balanced funds*: The investment objective of a balanced fund is to provide periodic returns and capital appreciation over a long period of time from a judicious mix of equity and debt instrument.
d) *Monthly Income Plans*: The primary investment objective of an MIP is to generate regular income through investments in fixed income securities so as

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[1] Lac is a million Indian rupees or about £12,000.

to make monthly payment or distribution to its unit holders.

e) *Gilt Funds*: A Guilt Fund seeks to provide investors current income consistent with a portfolio invested in securities created and issued by the central government and/ are the state governments.
f) *Liquid / Money Market Funds*: The investment objective of such funds is to generate income and capital appreciation by investing 100 per cent of the corpus in a diversified portfolio and debt and money market securities.
g) *Index Fund*: The primary investment objective of index funds is to is to invest in companies whose securities are included in a stock market index for e.g. S&P CNX Nifty Index.
h) *Sector Funds*: A sector Fund is devoted to investing in a single or a group of industries.
i) *Tax-saving Funds*: In India, The tax-saving funds are launched in the nature of Equity Linked savings scheme (ELSS).
j) *Miscellaneous funds*: A Mutual fund may designed a fund to meet the specific needs of different segments of society like children, senior citizens, girl child, retired people etc.

1.1.2 Functional Classification of Mutual Funds

On the basic of Functional classification of Mutual Funds, they may be classified in to open ended or closed-ended.

a) *Open-end Funds*: An open end fund offers units for sale on a continuous basis without specifying any duration for redemption and always stands ready to buy units issued by it at any time at a repurchase price.
b) *Closed-End Funds*: Closed-end Funds has a definite target amount, a fixed period of subscription and a fixed number of units that can be offered to the investors.

1.1.3 Geographical Classification of Mutual Funds

Mutual Funds that operate within the Countries' boundaries by mobilizing savings of their citizens within the country are called domestic Mutual Funds.

1.2 Benefits of mutual funds

An investment in mutual Funds offers several benefits to investors. Some of them are:

a) *Professional Management*: Investment in stock markets requires a thorough understanding of the markets, analysis of performance of the markets, analysis of performance of companies, industries and the economy as a whole which a lay investor may not be able to do on his own.
b) *Diversification*: Mutual funds are able to reduce risk of a portfolio by investing in a large number of companies across a broad cross section of industries and sectors.
c) *Easy Administration*: By investing in a mutual Fund an investor is able to avoid large amount of paper work and the problems associated with bad deliveries, delayed payments and follow up with brokers and companies.
d) *Higher Return Potential*: Over a medium to long-term period, mutual funds have the potential to provide a better return then what an average investor could earn on his own as they invest in a diversified basket of selected securities.
e) *Comparatively Low Costs*: Mutual Funds are a relatively less expensive way to invest compared to directly investing in the capital markets because the benefits of the scale in brokerage, custodial and other fees translate in to lower costs to investors.
f) *Easy Liquidity*: In an open-end scheme, an investor gets the money back promptly at net asset value (NAV) related prices from a mutual Fund.
g) *Transparency*: An investor gets regular information on the value of his investment in addition to disclosure on the specific investments made by his scheme, the proportion invested in each class of assets and the fund managers' investment strategy and outlook.
h) *Flexibility*: Through future such as regular investment plans, regular withdrawal plans and dividend reinvestment plans, an investor can systematically invest or with draw funds according to his needs and convenience.
i) *Affordability*: An investor individually may not have sufficient funds to invest in the

shares of blue-chip companies as they are highly priced.

j) *Operate in a Legal frame work*: All Mutual funds are required to be registered to be SEBI[2] and they function within the provision of SEBI (Mutual Funds) Regulations, 1996.

2. Results and Analysis

The data used are primary data. Table 1 refers to the distribution of the small investor respondents by their age. It is observed that the majority of the respondents (51.3 percent) are found in the age range of 31-50 years followed by 30 percent in the range of up to 30 years, and 18.3 percent in the range of above 50 years. Thus, the majority of the small investors are found to be relatively young.

Table 1. Age

Age	Frequency	Percent	Cumulative Percent
Up to 30	24	30.0	30.0
31-50	41	51.2	81.2
Above 50	15	18.8	100.0
Total	80	100.0	

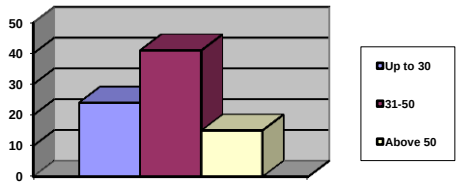

Table 2 refers to the distribution of the small investor respondents by their education. It is observed that 42.5 percent of the small investors are equipped with under graduation and 57.5 percent respondents are equipped with post graduation education. Thus, majority of the respondents are well educated.

Table 2. Education

Education	Frequency	Percent	Cumulative Percent
Under Graduate	34	42.5	42.5
Post Graduate	46	57.5	100.0
Total	80	100.0	

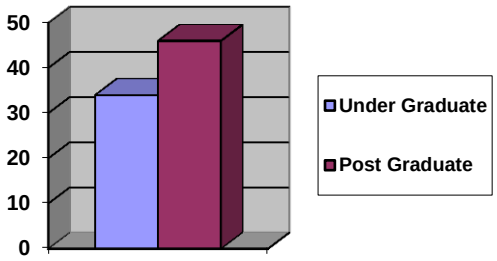

Table 3 refers to the distribution of the small investor respondents by their profession. It is observed that 41.3 percent of the small investors are from industry, 45 percent respondents are from business and 13.8 percent small investors are from services.

Table 3. Profession

Profession	Frequency	Percent	Cumulative Percent
Industry	33	41.3	41.3
Business	36	45.0	86.3
Service	11	13.7	100.0
Total	80	100.0	

[2] Securities and Exchange Board of India.

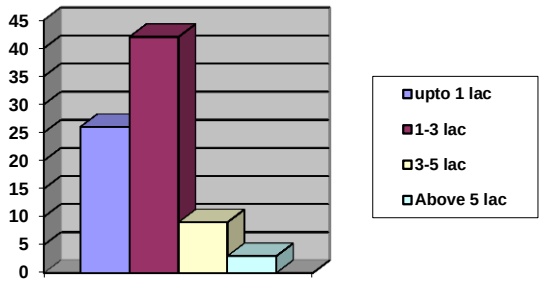

Table 4 refers to the distribution of the small investor respondents by their income. It is observed that 32.5 percent of the small investors are found in the income range of up to one lac followed by 52.5 percent respondents are in the income range of 1-3 lac, 11.3 percent in 3-5 lac and 3.8 percent from the income range of above 5 lac.

Table 4. Income

Income	Frequency	Percent	Cumulative Percent
Up to 1 lac	26	32.5	32.5
1-3 lac	42	52.5	85.0
3-5 lac	9	11.3	96.3
Above 5 lac	3	3.7	100.0
Total	80	100.0	

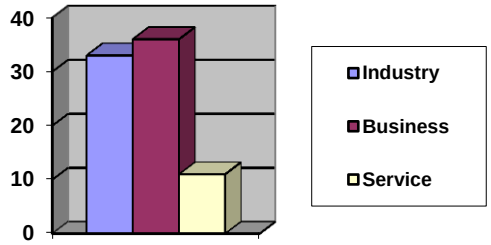

Table 5 refers to the distribution of the small investors by their preference to invest in growth funds. It is observed that 66.3 percent of the small investors have preferred to invest in growth funds and 33.7 percent respondents did not endorse the said preference.

Table 5. Growth Funds

Growth Funds	Frequency	Percent	Cumulative Percent
Yes	53	66.3	66.3
No	27	33.7	100.0
Total	80	100.0	

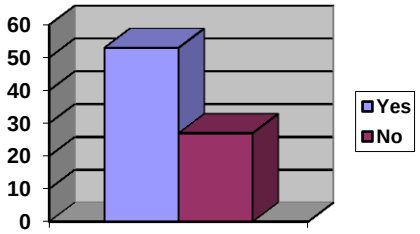

Table 6 refers to the distribution of the small investors by their preference to invest in income funds. It is observed that 58.8 percent of the small investors have preferred to invest in income funds and 41.2 percent respondents did not endorse the said preference.

Table 6. Income Funds

Income Funds	Frequency	Percent	Cumulative Percent
Yes	47	58.8	58.8
No	33	41.2	100.0
Total	80	100.0	

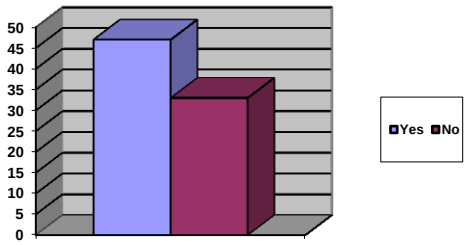

Table 7 refers to the distribution of the small investors by their preference to invest in balanced funds. It is observed that 37.5 percent of the small investors have preferred to invest in balanced funds and 62.5 percent respondents did not endorse the said preference.

Table 7. Balanced Funds

Balanced Funds	Frequency	Percent	Cumulative Percent
Yes	30	37.5	37.5
No	50	62.5	100.0
Total	80	100.0	

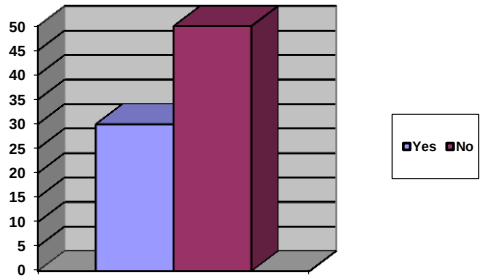

Table 8 refers to the distribution of the small investors by their preference to invest in monthly income plans. It is observed that 48.8 percent of the small investors have preferred to invest in monthly income plans and 51.3 percent respondents did not endorse the said preference.

Table 8. Monthly income Plans

Monthly Income Plans	Frequency	Percent	Cumulative Percent
Yes	39	48.8	48.8
No	41	51.3	100.0
Total	80	100.0	

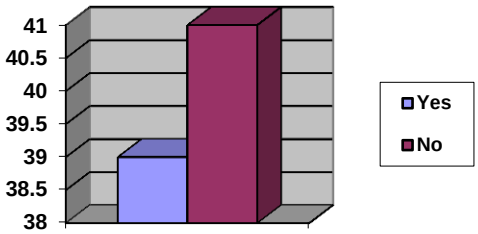

Table 9 refers to the distribution of the small investors by their preference to invest in gilt funds. It is observed that 38.8 percent of the small investors have preferred to invest in gilt funds and 61.3 percent respondents did not endorse the said preference.

Table 9. Gilt Funds

Gilt Funds	Frequency	Percent	Cumulative Percent
Yes	31	38.8	38.8
No	49	61.3	100.0
Total	80	100.0	

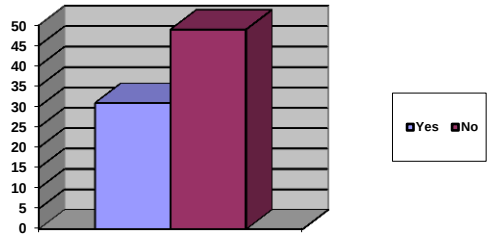

Table 10 refers to the distribution of the small investors by their preference to invest in money market/ liquid funds. It is observed that 66.3 percent of the small investors have preferred to invest in money market/ liquid funds and 33.7 percent respondents did not endorse the said preference.

Table 10. Liquid/Money Market Funds

Liquid/ Money Market Funds	Frequency	Percent	Cumulative Percent
Yes	53	66.3	66.3
No	27	33.7	100.0
Total	80	100.0	

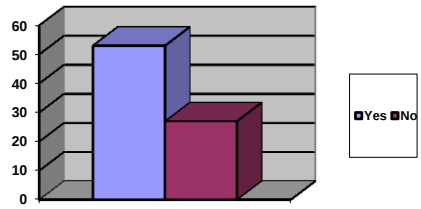

Table 11 refers to the distribution of the small investors by their preference to invest in index funds. It is observed that 55 percent of the small investors have preferred to invest in index funds and 45 percent respondents did not endorse the said preference.

Table 11. Index Funds

Index Funds	Frequency	Percent	Cumulative Percent
Yes	44	55.0	55.0
No	36	45.0	100.0
Total	80	100.0	

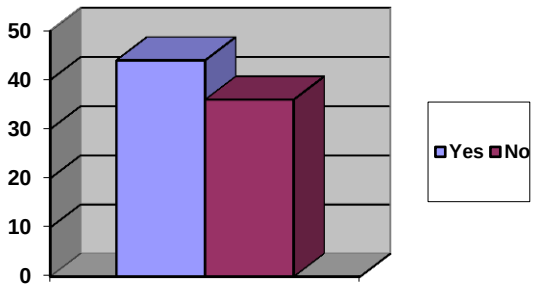

Table 12 refers to the distribution of the small investors by their preference to invest in sector funds. It is observed that 43.8 percent of the small investors have preferred to invest in sector funds and 56.2 percent respondents did not endorse the said preference.

Table 12. Sector Funds

Sector Funds	Frequency	Percent	Cumulative Percent
Yes	35	43.8	43.8
No	45	56.2	100.0
Total	80	100.0	

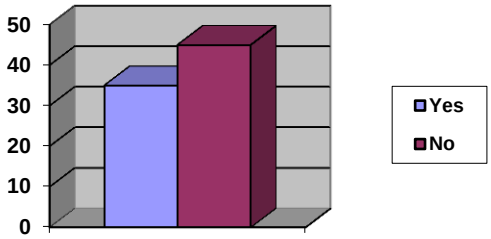

Table 13 refers to the distribution of the small investors by their preference to invest in tax saving funds. It is observed that 51.3 percent of the small investors have preferred to invest in tax saving funds and 48.7 percent respondents did not endorse the said preference.

Table 13. Tax Saving Funds

Tax Saving Funds	Frequency	Percent	Cumulative Percent
Yes	41	51.3	51.3
No	39	48.7	100.0
Total	80	100.0	

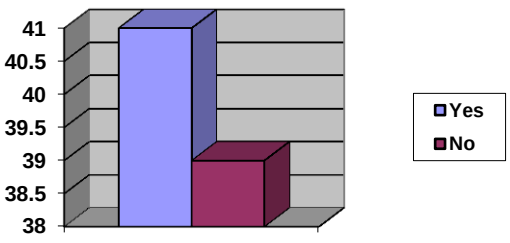

Table 14 refers to the distribution of the small investors by their preference to invest in open end funds. It is observed that 63.8 percent of the small

investors have preferred to invest in open end funds and 36.2 percent respondents did not endorse the said preference.

Table 14. Open End Funds

Open End Funds	Frequency	Percent	Cumulative Percent
Yes	51	63.8	63.8
No	29	36.2	100.0
Total	80	100.0	

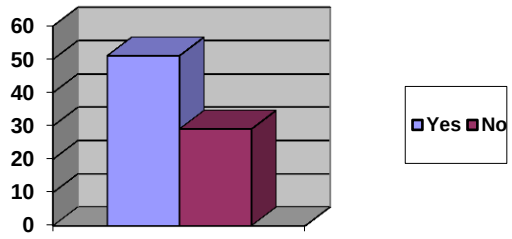

Table 15 refers to the distribution of the small investors by their preference to invest in closed end funds. It is observed that 30 percent of the small investors have preferred to invest in closed end funds and 70 percent respondents did not endorse the said preference.

Table 15. Closed End Funds

Closed End Funds	Frequency	Percent	Cumulative Percent
Yes	24	30.0	30.0
No	56	70.0	100.0
Total	80	100.0	

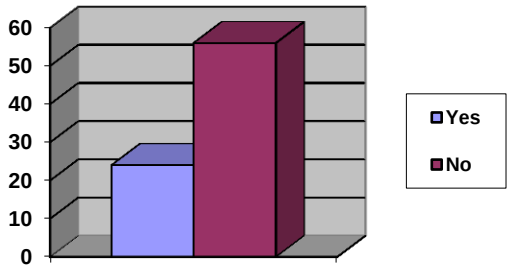

Table 16 refers to the joint distribution of the small investors by their age and by their preference to invest in growth funds. The correlation between the age of the respondents and their preference to invest in growth funds is positive (r = 0.130). The rejection of the null hypothesis with level of significance = 0.05 and degree of freedom = 2 implies that their preferences to invest in growth funds is statistically dependent of the respondents age.

Table 16. Growth Funds

Age	Growth Funds		Total
	Yes	No	
Upto 30	20	4	24
	83.3%	16.7%	100.0%
	37.7%	14.8%	30.0%
31-50	22	19	41
	53.7%	46.3%	100.0%
	41.5%	70.4%	51.3%
Above 50	11	4	15
	73.3%	26.7%	100.0%
	20.8%	14.8%	18.8%
Total	53	27	80
	66.3%	33.8%	100.0%
	100.0%	100.0%	100.0%

Chi-Square= 6.376, df=2, ρ=0.046, r=0.130

Table 17 refers to the joint distribution of the small investors by their age and by their preference to invest in income funds. The correlation between the age of the respondents and their preference to invest in income funds is positive (r = 0.024). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom = 2 implies that the age of the respondents and their preference to invest in income funds are statistically independent.

Table 17. Age and Income Funds

Age	Income Funds		Total
	Yes	No	
Upto 30	14	10	24
	58.3%	41.7%	100.0%
	29.8%	30.3%	30.0%
31-50	25	16	41
	61.0%	39.0%	100.0%
	53.2%	48.5%	51.3%
Above 50	8	7	15
	53.3%	46.7%	100.0%
	17.0%	21.2%	18.8%
Total	47	33	80
	58.8%	41.3%	100.0%
	100.0%	100.0%	100.0%

Chi-Square= 0.267, df=2, ρ=0.875, r=0.024

Table 18 refers to the joint distribution of the small investors by their age and by their preference to invest in balanced funds. The correlation between the age of the respondents and their preference to invest in balanced funds is negative (r = -0.042). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom = 2 implies that the age of the respondents and their preference to invest in balanced funds are statistically independent.

Table 18. Age and Balanced Funds

Age	Balanced Funds		Total
	Yes	No	
Upto 30	10	14	24
	41.7%	58.3%	100.0%
	33.3%	28.0%	30.0%
31-50	12	29	41
	29.3%	70.7%	100.0%
	40.0%	58.0%	51.3%
Above 50	8	7	15
	53.3%	46.7%	100.0%
	26.7%	14.0%	18.8%
Total	30	50	80
	37.5%	62.5%	100.0%
	100.0%	100.0%	100.0%

Chi-Square= 2.968, df=2, ρ=0.227, r=-0.042

Table 19 refers to the joint distribution of the small investors by their age and by their preference to invest in monthly income plans. The correlation between the age of the respondents and their preference to invest in monthly income plans is negative (r = -0.017). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom = 2 implies that the age of the respondents and their preference to invest in monthly income plans are statistically independent.

Table 19. Age and Monthly income Plans

Age	Monthly income Plans		Total
	Yes	No	
Upto 30	11	13	24
	45.8%	54.2%	100.0%
	28.2%	31.7%	30.0%
31-50	21	20	41
	51.2%	48.8%	100.0%
	53.8%	48.8%	51.3%
Above 50	7	8	15
	46.7%	53.3%	100.0%

	17.9%	19.5%	18.8%
Total	39	41	80
	48.8%	51.3%	100.0%
	100.0%	100.0%	100.0%

Chi-Square= 0.208, df=2, ρ=0.901, r=-0.017

Table 20 refers to the joint distribution of the small investors by their age and by their preference to invest in gilt funds. The correlation between the age of the respondents and their preference to invest in gilt funds is negative (r = - 0.166). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom = 2 implies that the age of the respondents and their preference to invest in gilt funds are statistically independent.

Table 20. Age and Gilt Funds

Age	Gilt Funds		Total
	Yes	No	
Upto 30	7	17	24
	29.2%	70.8%	100.0%
	22.6%	34.7%	30.0%
31-50	16	25	41
	39.0%	61.0%	100.0%
	51.6%	51.0%	51.3%
Above 50	8	7	15
	53.3%	46.7%	100.0%
	25.8%	14.3%	18.8%
Total	31	49	80
	38.8%	61.3%	100.0%
	100.0%	100.0%	100.0%

Chi-Square= 2.274, df=2, ρ=0.321, r=-0.166

Table 21 refers to the joint distribution of the small investors by their age and by their preference to invest in liquid/money market funds. The correlation between the age of the respondents and their preference to invest in liquid/money market funds is negative (r=-0.126). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom = 2 implies that the age of the respondents and their preference to invest in liquid/money market funds are statistically independent.

Table 21. Age and Liquid / Money Market Funds

Age		Liquid / Money Market Funds		Total
		Yes	No	
	Upto 30	12	12	24
		50.0%	50.0%	100.0%
		22.6%	44.4%	30.0%
	31-50	32	9	41
		78.0%	22.0%	100.0%
		60.4%	33.3%	51.3%
	Above 50	9	6	15
		60.0%	40.0%	100.0%
		17.0%	22.2%	18.8%
Total		53	27	80
		66.3%	33.8%	100.0%
		100.0%	100.0%	100.0%

Chi-Square = 5.649, df=2, ρ = 0.059, r = -0.126

Table 22 refers to the joint distribution of the small investors by their age and by their preference to invest in index funds. The correlation between the age of the respondents and their preference to invest in index funds is positive (r = 0.189). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom = 2 implies that the age of the respondents and their preference to invest in index funds are statistically independent.

Table 22. Age and Index Funds

Age		Index Funds		Total
		Yes	No	
Upto 30		17	7	24
		70.8%	29.2%	100.0%
		38.6%	19.4%	30.0%
31-50		20	21	41
		48.8%	51.2%	100.0%
		45.5%	58.3%	51.3%
Above 50		7	8	15
		46.7%	53.3%	100.0%
		15.9%	22.2%	18.8%
Total		44	36	80
		55.0%	45.0%	100.0%
		100.0%	100.0%	100.0%

Chi-Square= 3.493, df=2, ρ=0.174, r=0.189

Table 23 refers to the joint distribution of the small investors by their age and by their preference to invest in sector funds. The correlation between the age of the respondents and their preference to invest in sector funds is positive (r=0.038). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom = 2 implies that the age of the respondents and their preference to invest in sector funds are statistically independent.

Table 23. Age and Sector Funds

Age		Sector Funds		Total
		Yes	No	
Upto 30		11	13	24
		45.8%	54.2%	100.0%
		31.4%	28.9%	30.0%
31-50		18	23	41
		43.9%	56.1%	100.0%
		51.4%	51.1%	51.3%
Above 50		6	9	15
		40.0%	60.0%	100.0%
		17.1%	20.0%	18.8%
Total		35	45	80
		43.8%	56.3%	100.0%
		100.0%	100.0%	100.0%

Chi-Square = 0.128, df = 2, ρ = 0.938, r = 0.038

Table 24 refers to the joint distribution of the small investors by their age and by their preference to invest in tax saving funds. The correlation between the age of the respondents and their preference to invest in tax saving funds is negative (r=-0.055). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom=2 implies that the age of the respondents and their preference to invest in tax saving funds are statistically independent.

Table 24. Age and Tax Saving Funds

Age		Tax Saving Funds		Total
		Yes	No	
Upto 30		12	12	24
		50.0%	50.0%	100.0%
		29.3%	30.8%	30.0%
31-50		20	21	41
		48.8%	51.2%	100.0%
		48.8%	53.8%	51.3%
Above 50		9	6	15
		60.0%	40.0%	100.0%
		22.0%	15.4%	18.8%
Total		41	39	80
		51.3%	48.8%	100.0%

		100.0%	100.0%	100.0%

Chi-Square= 0.575, df=2, ρ=0.750, r=-0.055

Table 25 refers to the joint distribution of the small investors by heir age and by their preference to invest in open end funds. The correlation between the age of the respondents and their preference to invest in open end funds is positive (r=0.260). The rejection of the null hypothesis with level of significance = 0.05 and degree of freedom = 2 implies that their preference to invest in open end funds is statistically dependent of the age of the respondents.

Table 25. Age and Open End Funds

Age		Open End Funds		Total
		Yes	No	
Upto 30		17	7	24
		70.8%	29.2%	100.0%
		33.3%	24.1%	30.0%
31-50		30	11	41
		73.2%	26.8%	100.0%
		58.8%	37.9%	51.3%
Above 50		4	11	15
		26.7%	73.3%	100.0%
		7.8%	37.9%	18.8%
Total		51	29	80
		63.8%	36.3%	100.0%
		100.0%	100.0%	100.0%

Chi-Square=11.022, df=2, ρ=0.004, r=0.260

Table 26 refers to the joint distribution of the small investors by their age and by their preference to invest in closed end funds. The correlation between the age of the respondents and their preference to invest in closed end funds is positive (r=0.021). The acceptance of the null hypothesis with level of significance= 0.05 and degree of freedom=2 implies that the age of the respondents and their preference to invest in closed end funds are statistically independent.

Table 26: Age and Closed End Funds

Age		Closed End Funds		Total
		Yes	No	
Upto 30		9	15	24
		37.5%	62.5%	100.0%
		37.5%	26.8%	30.0%
31-50		9	32	41
		22.0%	78.0%	100.0%
		37.5%	57.1%	51.3%
Above 50		6	9	15
		40.0%	60.0%	100.0%
		25.0%	16.1%	18.8%
Total		24	56	80
		30.0%	70.0%	100.0%
		100.0%	100.0%	100.0%

Chi-Square= 2.622, df=2, ρ=0.270, r=0.021

Table 27 refers to the joint distribution of the small investors by their income and by their preference to invest in growth funds. The correlation between the income of the respondents and their preference to invest in growth funds is negative (r= -0.374). The rejection of the null hypothesis with level of significance= 0.05 and degree of freedom=3 implies that their preference to invest in growth funds is statistically dependent of the income of the respondents.

Table 27. Income and Growth Funds

Income		Growth Funds		Total
		Yes	No	
upto 1 lac		11	15	26
		42.3%	57.7%	100.0%

	20.8%	55.6%	32.5%
1-3 lac	31	11	42
	73.8%	26.2%	100.0%
	58.5%	40.7%	52.5%
3-5 lac	8	1	9
	88.9%	11.1%	100.0%
	15.1%	3.7%	11.3%
Above 5 lac	3		3
	100.0%		100.0%
	5.7%		3.8%
Total	53	27	80
	66.3%	33.8%	100.0%
	100.0%	100.0%	100.0%

Chi-Square=11.330, df=3, ρ=0.010, r=-0.374

Table 28 refers to the joint distribution of the small investors by their income and by their preference to invest in income funds. The correlation between the income of the respondents and their preference to invest in income funds is positive (r= 0.177). The rejection of the null hypothesis with level of significance= 0.05 and degree of freedom=3 implies that their preference to invest in income funds is statistically dependent of the income of the respondents.

Table 28. Income and Income Funds

Income	Income Funds		Total
	Yes	No	
upto 1 lac	22	4	26
	84.6%	15.4%	100.0%
	46.8%	12.1%	32.5%
1-3 lac	15	27	42
	35.7%	64.3%	100.0%
	31.9%	81.8%	52.5%
3-5 lac	7	2	9
	77.8%	22.2%	100.0%
	14.9%	6.1%	11.3%
Above 5 lac	3		3
	100.0%		100.0%
	6.4%		3.8%
Total	47	33	80
	58.8%	41.3%	100.0%
	100.0%	100.0%	100.0%

Chi-Square= 19.825, df=3, ρ=000, r=0.177

Table 29 refers to the joint distribution of the small investors by their income and by their preference to invest in balanced funds. The correlation between the income of the respondents and their preference to invest in balanced funds is positive (r= 0.059). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom=3 implies that the income of the respondents and their preference to invest in balanced funds are statistically independent.

Table 29. Income and Balanced Funds

Income	Balanced Funds		Total
	Yes	No	
upto 1 lac	10	16	26
	38.5%	61.5%	100.0%
	33.3%	32.0%	32.5%
1-3 lac	17	25	42
	40.5%	59.5%	100.0%
	56.7%	50.0%	52.5%
3-5 lac	2	7	9
	22.2%	77.8%	100.0%
	6.7%	14.0%	11.3%
Above 5 lac	1	2	3
	33.3%	66.7%	100.0%

	3.3%	4.0%	3.8%
Total	30	50	80
	37.5%	62.5%	100.0%
	100.0%	100.0%	100.0%

Chi-Square= 1.088, df=3, ρ=0.780, r=0.059

Table 30 refers to the joint distribution of the small investors by their income and by their preference to invest in monthly income plans. The correlation between the income of the respondents and their preference to invest in monthly income plans is negative (r= -0.107). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom = 3 implies that the income of the respondents and their preference to invest in monthly income plans are statistically independent.

Table 30. Income and Monthly income Plans

Income		Monthly income Plans		Total
		Yes	No	
upto 1 lac		11	15	26
		42.3%	57.7%	100.0%
		28.2%	36.6%	32.5%
1-3 lac		21	21	42
		50.0%	50.0%	100.0%
		53.8%	51.2%	52.5%
3-5 lac		5	4	9
		55.6%	44.4%	100.0%
		12.8%	9.8%	11.3%
Above 5 lac		2	1	3
		66.7%	33.3%	100.0%
		5.1%	2.4%	3.8%
Total		39	41	80
		48.8%	51.3%	100.0%
		100.0%	100.0%	100.0%

Chi-Square=1.010, df=3, ρ=0.799, r=-0.107

Table 31 refers to the joint distribution of the small investors by their income and by their preference to invest in gilt funds. The correlation between the income of the respondents and their preference to invest in gilt funds is positive (r= 0.172). The acceptance of the null hypothesis with level of significance= 0.05 and degree of freedom=3 implies that the income of the respondents and their preference to invest in gilt funds are statistically independent.

Table 31. Income and Gilt Funds

Income		Gilt Funds		Total
		Yes	No	
upto 1 lac		12	14	26
		46.2%	53.8%	100.0%
		38.7%	28.6%	32.5%
1-3 lac		17	25	42
		40.5%	59.5%	100.0%
		54.8%	51.0%	52.5%
3-5 lac		2	7	9
		22.2%	77.8%	100.0%
		6.5%	14.3%	11.3%
Above 5 lac			3	3
			100.0%	100.0%
			6.1%	3.8%
Total		31	49	80
		38.8%	61.3%	100.0%
		100.0%	100.0%	100.0%

Chi-Square= 3.587, df=3, ρ=0.310, r=0.172

Table 32 refers to the joint distribution of the small investors by their income and by their preference to invest in liquid/money market funds. The correlation between the income of the respondents and their preference to invest in liquid/money market funds is positive (r= -0.104). The acceptance of the null hypothesis with level of

significance= 0.05 and degree of freedom=3 implies that the income of the respondents and their preference to invest in liquid/money market funds are statistically independent.

Table 32. Income and Liquid / Money Market Funds

Income		Liquid/Money Market Funds		Total
		Yes	No	
upto 1 lac		18	8	26
		69.2%	30.8%	100.0%
		34.0%	29.6%	32.5%
1-3 lac		29	13	42
		69.0%	31.0%	100.0%
		54.7%	48.1%	52.5%
3-5 lac		5	4	9
		55.6%	44.4%	100.0%
		9.4%	14.8%	11.3%
Above 5 lac		1	2	3
		33.3%	66.7%	100.0%
		1.9%	7.4%	3.8%
Total		53	27	80
		66.3%	33.8%	100.0%
		100.0%	100.0%	100.0%

Chi-Square= 2.164, df=3, ρ=0.539, r=0.104

Table 33 refers to the joint distribution of the small investors by their income and by their preference to invest in index funds. The correlation between the income of the respondents and their preference to invest in index funds is negative (r=-0.023). The acceptance of the null hypothesis with level of significance= 0.05 and degree of freedom = 3 implies that the income of the respondents and their preference to invest in index funds are statistically independent.

Table 33. Income and Index Funds

Income		Index Funds		Total
		Yes	No	
upto 1 lac		13	13	26
		50.0%	50.0%	100.0%
		29.5%	36.1%	32.5%
1-3 lac		25	17	42
		59.5%	40.5%	100.0%
		56.8%	47.2%	52.5%
3-5 lac		6	3	9
		66.7%	33.3%	100.0%
		13.6%	8.3%	11.3%
Above 5 lac			3	3
			100.0%	100.0%
			8.3%	3.8%
Total		44	36	80
		55.0%	45.0%	100.0%
		100.0%	100.0%	100.0%

Chi-Square= 4.772, df=3, ρ=0.189, r=-0.023

Table 34 refers to the joint distribution of the small investors by their income and by their preference to invest in sector funds. The correlation between the income of the respondents and their preference to invest in sector funds is negative (r=-0.235). The acceptance of the null hypothesis with level of significance = 0.05 and degree of freedom=3 implies that the income of the respondents and their preference to invest in sector funds are statistically independent.

Table 34. Income and Sector Funds

Income		Sector Funds		Total
		Yes	No	
upto 1 lac		8	18	26
		30.8%	69.2%	100.0%
		22.9%	40.0%	32.5%
1-3 lac		19	23	42
		45.2%	54.8%	100.0%
		54.3%	51.1%	52.5%
3-5 lac		5	4	9
		55.6%	44.4%	100.0%
		14.3%	8.9%	11.3%
Above 5 lac		3		3
		100.0%		100.0%
		8.6%		3.8%
Total		35	45	80
		43.8%	56.3%	100.0%
		100.0%	100.0%	100.0%

Chi-Square= 6.185, df=3, ρ=0.103, r=-0.235

3. Concluding Remarks

It is concluded that the majority of the small investors are relatively young, equipped with high level education. All of them are employed and are found in the income range of up to 3 lac income. The majority of the small investors preferred to invest in growth funds followed by open end funds, money market instruments, balanced funds, and income funds in the order. The age of the small investors and their preference portfolio of mutual funds by the small investors are statistically independent except in the case of the preference of investments in growth funds and open end funds. The income of the small investors and the preference portfolio of mutual funds by the small investors are statistically independent except in the case of preference of investments in growth funds and income funds.

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Crime and the (Mediterranean) City: Exploring the Geography of (In) Security in Rome, Italy

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Abstract **- The spatial distribution of a selection of crime and demographic indicators in urban and suburban Rome, Italy, was explored in this paper to correlate socioeconomic conditions with urban deviance at local scale. An index of crime concentration was derived at district scale by composing all crime indicators. A principal components analysis was undertaken to correlate crime indicators with the socioeconomic context described through economic and demographic variables, living conditions, and the environmental quality. The geographical distribution of crime in Rome showed a pattern mainly associated to variables including population density, settlement form (compact *vs* dispersed), income, and unemployment. The spatial distribution of some crime indicators was finally compared with the citizens' perception of security as it was measured by a specific field survey carried out at the same spatial scale. The paper illustrates that the integration between statistical data and qualitative information collected through field observation is an effective tool to inform policies contrasting criminality at local scale.**

Keywords *- Suburbanization, Socioeconomic structure, Crime severity, Composite indicators, Rome.*

1. Introduction

In the contemporary urban society the demand for citizen's security is widespread and only partially associated to the effective level of criminality or proneness to criminality (Barkan, 1997). This is particularly true in cities that have experienced massive immigration processes, as it was recently observed in several northern Mediterranean cities (e.g. Maloutas, 2007). In urban areas cities, violent crime spreading together with (illegal) immigration may contribute to create a 'landscape of insecurity' especially permeating the marginal suburban areas (Serafino, 2008). Opposite to this pattern, crime distribution usually follows a core-periphery pattern decreasing from the inner city (where the main economic functions are concentrated) to the suburban area (Sampson and Wilson, 1995). The distribution of crime along the urban-rural gradient can be thus monitored in order to explore the possible *mismatch* between the perception of crime severity and the spatial distribution of recorded crimes (Brown, 2007).

To this respect, Rome is a reliable case study as it represents the biggest Italian city in terms of demographic size, population growth, and territorial surface. Moreover, Rome has been the final destination of massive immigration flows in last years determining changes in the social geography of the city (Mudu, 2006a). Notably, while central Italy has been regarded in past as a traditional 'land of emigration', since the early-1990s, it started hosting important flows of migrants, especially from Albania, Romania, and northern Africa, which concentrated in the outskirts of Rome. Precarious conditions of life, unemployment, and conflicts with the local population thrive the quality of life of several migrants compared to indigenous people and could influence the feeling of insecurity in the resident population. This can be observed either in economically-disadvantaged peri-urban settlements and in the affluent urban districts (Cope and Latcham, 2009).

Since relatively little is known about the spatial distribution of crime in the Mediterranean city, the present paper contributes to this issue by exploring the possible *mismatch* between the perception (of) and the statistically-measured exposure (to) crime at local scale (Furstenburg, 1971). In details, the present study

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analyses the spatial distribution of several crime types in urban and suburban Rome with the aim of (i) classifying the investigated area according to the intensity, severity, and spread of crime, (ii) testing the association among crime variables and several socio-economic indicators and, finally, (iii) correlating the geography of (in)security as assessed by a field survey with the spatial distribution of crime records.

2. Methods

2.1 Data Sources

Criminal records were obtained from the Statistical Office of Rome municipality at each of the city boroughs. Boroughs were chosen in this study as the spatial domain since allows for a relatively detailed geographical analysis of crime concentration at a scale which is easily interpretable by non-technical users. At that date Rome's municipality, which actually covers nearly 1.285 km^2, was subdivided into nineteen boroughs (the so called 'municipi', Figure 1). The first borough covers the ancient city centre of Rome. The second and third boroughs include the modern city centre. The seventeenth borough covers the inner city surrounding the Vatican State. The remaining boroughs include the compact peripheral areas (i.e. V, VI, VII, IX, XIII boroughs) and the sprawled suburbs (i.e. IV, VIII, X, XI, XII, XV, XVI, XVIII, XIX, XX boroughs) of Rome.

2.2 Crime Indicators

Following a standard crime classification, three main categories of crimes were considered here: (i) violent crime (murder, attempted murder, assault, injury, and sexual assault), (ii) property crime (robbery, theft), and (iii) production and selling of drugs (see the complete list reported in Table 1). The related indicators were calculated as percentages (i.e. by dividing the number of crimes by the total number of resident people in each borough). The gross crime index was then calculated at the same spatial scale by summing all crime records and dividing this value by the resident population. Crime distribution by type and severity was analysed using descriptive statistics and maps. We used crime data referred to 2001 in order to compare them with socio-economic data derived from additional sources and collected at the same date. A diachronic analysis (1999-2001) of crime records showed that no significant variation occurred in crime rate during the three consecutive years in Rome (data not shown).

Twenty-three variables were calculated from the National Census of Households and Buildings (2001) to depict the socioeconomic conditions observed in Rome's boroughs. These variables cover the following themes: demography, immigration, labour market, district value added, education, and the environmental quality (see list in Table 3). Two additional indicators were derived from a field survey carried out in 2000 over a representative sample of households living in Rome. The survey was aimed at studying the perception of crime severity among Rome's citizens (Mignella Calvosa, 2001).

2.3 Statistical Analysis

Pair-wise Spearman rank tests were carried out at borough scale to analyze the spatial distribution of crime indicators. A Principal Components Analysis (PCA) was carried out separately on crime and socioeconomic variables in order to summarize the most important features of Roman boroughs in the two research dimensions. The number of significant axes was chosen according to the PCA explained variance. A pair-wise Spearman rank test was carried out at the borough scale with the aim of checking correlations between the selected crime indicators and boroughs' factor scores on the two most significant axes extracted by the PCA. The probability level in all Spearman rank tests was determined using Bonferroni correction. Finally, Spearman correlations were also used to verify if the crime distribution by type and borough was associated to higher levels of (in)security among citizens as revealed by the field survey described above.

3. Results

3.1 The Geographical Distribution of Crime in Rome

The spatial distribution of crime indicators in Rome was reported in Table 1. The first borough ranked the highest in the gross crime rate. Notably, this index was found high in all boroughs close to the inner city (Figure 2) and in the thirteen borough, a compact urban district located on the sea coast. Crime rate distribution did not follow the urban-rural gradient being influenced by population density, settlement form (compact *vs* dispersed), income, and unemployment.

As far as the crime typology is concerned, the index quantifying the distribution of violent crimes showed a quite different spatial pattern compared to the gross crime index (Figure 3). This kind of crime was found scarce in the city centre while increasing along the north-east industrial districts and in the

coastal area. This spatial pattern may be associated with the disadvantaged socioeconomic conditions of the eastern part of the city, as a result of the processes of social segregation occurring in Rome since 1950s. The robbery rate showed a quite different spatial pattern compared to that observed for violent crimes, and approaches the distribution of the gross crime rate. The highest values of this indicator have been observed in the inner city and in the first-ring boroughs.

The spatial association between crime indicators was studied by Spearman rank correlation tests (Table 2). The gross crime rate was found associated with several crime types but murders, some types of robberies, and prostitution, suggesting that these crimes show a different spatial distribution at the scale analysed in this study. By the contrary, violent crimes and those against property showed a similar distribution since their pair-wise correlation coefficients were found always positive and significant.

A composite crime index was finally derived from results of the PCA carried out on the whole set of crime indicators collected at the borough level. PCA extracted four significant axes, among which the two main axes explained 75% of the total variance (respectively 65% and 10%). The third and fourth axes were found relatively less important (7% and 6%, respectively). Table 3 reports the loadings of crime indicators to the main axes of PCA. The gross crime rate and several other indicators of crime, both violent crimes and those against the property, were found positively correlated to the first axis. Prostitution, robberies in post offices and in jewelleries were associated to the second axis. The first axis clearly segregated Rome boroughs within the income gradient. The inner boroughs clustered on the positive values of the axis (Figure 4). Low-density boroughs were found associated to negative values of the axis, while compact peripheral districts clustered on the positive side of this axis.

3.2 The Analysis of the Socioeconomic Conditions at Local Scale

Table 4 illustrates the distribution of the twenty-three socioeconomic indicators calculated at each borough and Table 5 reports the main results of the PCA applied to these indicators. The first two components accounted for a relevant part of the total variance (66% in total: 52% and 14%, respectively). The third and fourth components were found relatively less important (11% and 7%, respectively).

The first axis classified Rome boroughs according to their socio-demographic characteristics (e.g. family size, people outside primary education, unemployment rate, number of resident people *per* room). The axis segregated the city boroughs into a east-west gradient. Positive values of the axis indicate the most disadvantaged boroughs, which are generally located in the eastern part of the city. The more affluent boroughs (i.e. I, II, III, IX, and XVII boroughs) were found associated to negative values of the axis.

The second axis depicted a subtle gradient which integrates additional socioeconomic aspects and variables depicting the environmental quality of each district. In synthesis, the axis illustrated an urban-rural gradient which can be associated to the different housing patterns of the resident and foreign people. Apart from the first borough, the positive values of this axis segregated the green and low-density boroughs which are especially located in the northern and southern part of the city. All eastern boroughs and some boroughs from the south-western area of Rome were found associated to the negative values of the axis. All low-income boroughs (i.e. V, VII, X, XII, and XV boroughs) and three boroughs with an intermediate level of *per capita* income were located within the positive values of the axis (Figure 5), while the compact residential boroughs (high population density and low *per capita* green surface area) clustered on the negative side of this axis.

3.3 Crime Indicators and the Socioeconomic Conditions in Rome

The correlation between the factor scores of the two axes extracted by the ‘socio-economic’ PCA and some selected crime indicators was analysed in Table 6. Significant correlations were detected only between the scores of the first axis and some selected crime indicators. The gross crime rate showed a negative correlation with the first PCA axis. Although the significance of the correlation varied a lot, the same sign of correlation was observed for all considered indicators. As the first axis clearly described the socioeconomic conditions of the city boroughs (e.g. demographic structure, income, immigration, labour market, poverty), it should be clear that this axis may provide important indications in order to model scenarios of crime distribution and concentration.

3.4 Crime Distribution and the Feeling of (In)security in Rome

The results of the field survey carried out on a sample of households residing in Rome indicated that the perception of citizens is different, on average,

when asking about the safety of the district where they live and that of the whole city. Only 32% of households thought that Rome is safe while 62% declared that their district is safe (Table 7). Although a strong correlation was found between the two variables (Figure 6), these percentages showed a marked variation among Rome boroughs. People living in the inner boroughs said that their district is safe more frequently than people living in peripheral or low-income districts.

The correlation observed between crime indicators and the two variables recorded in the field survey suggests that a 'decoupling' process exists in Rome between the feeling of (in)security of citizens and the observed crime rate. As an example, the indicators of violent crime concentration and those against the property were found correlated to a higher 'yes' response rate when asking if the city (and even the district) where the respondent lives is safe (Table 8). The positive relationship between the variables recorded within the field survey and the distribution of the gross crime index (Figure 7) confirms this pattern.

4. Discussion

Crime concentration and severity were found spatially varying in Rome (Mignella Calvosa, 2004). As an example, the gross crime rate showed a marked variability which is linked with the socioeconomic structure of the city. As observed in other Mediterranean cities (Leontidou, 1990; Barata Salgueiro, 2001; Dura-Guimera, 2003; Muñoz, 2003), Rome experienced a process of social segregation influencing the urban geography of the City since the early-1950s (Seronde Babonaux, 1983). At now, however, Rome cannot be treated as a polarised city by searching for traditional gradients such as core-periphery, urban-rural, income (Violante, 2008). Recent analyses have warned on the use of such binary categories in socially complex metropolitan areas (Mudu, 2006b). This complex urban picture confirms the usefulness of an integrated exploratory approach based on geographical and statistical analyses to assess the distribution, concentration, and severity of crime in Rome.

By looking at the district data, the first borough (which covers the ancient city within the 'Aurelian Walls') was top-ranking in crime concentration, confirming literature findings (e.g. O'Sullivan, 2003). This borough traditionally concentrates most of the tourism flows, hotels, restaurants, shops, boutiques, and commercial centres. The area covers part of the central business district, with the main railway station, the major churches, and several governmental offices. The first borough includes the districts of 'Testaccio', 'Esquilino', and 'Trastevere', which are rapidly changing their social traits due to the recovery of some industrial or abandoned places, and the occupation of old buildings by foreign people. One typical example is the blocks close to 'Piazza Vittorio' holding the ancient central market (Mudu, 2006a). All these features may be factors influencing the higher crime rate found in the first borough compared to that observed in the neighbouring boroughs.

As the multivariate analysis indicates, Rome can be considered as a 'mosaic crime city'. The quality of the dwellings, the infrastructures, the distribution of green areas, as well as the district value added are potential determinants of crime distribution in the urban area of Rome (Eisner and Wikstrom, 1999; Appiahene-Gyamfi, 2003; Ackerman et al., 2004; Hojman, 2004; Rotolo and Tittle, 2006). However, while important differences in crime distribution, concentration, and severity exist in the city, the feeling of insecurity expressed by citizens seems not to follow the same pattern: suburban areas are perceived as prone to the same (or even higher) level of risk than the inner city (Mignella Calvosa, 2001).

The debate on security, fear of crime, and victimisation originated in the early 1990s is currently on going (e.g. Robert, 1990; Lagrange, 1993; Walklate, 1998). This study does not question if official statistics are true and crime perceptions are false because they do not match official statistics. The issues of production of criminal statistics and security discourses are much more complicated (Deflem, 1997) and both are social constructions (Walklate, 1997). We prefer to consider this mismatch as a starting point for future interpretations of the 'urban crime landscape' (Serafino, 2008). As a matter of fact, the connection between crime and the city refers to crime that is 'visible', 'on the street' and against personal property. The other crime – like white collars crime, domestic violence and so on – are only partially quantifiable. This connection may be perceived as an arising association between crime and 'dangerousness', because promotes a concept of 'class apart' when identifying unknown people, especially foreign people (Rostami Tabrizi and Madanipour, 2006). For this reason, uncontrolled immigration can impact on the perception of urban security. The cases of xenophobia and migrant riots in Paris 'banlieux', the racist assaults in Rome 'borgate', and similar phenomena observed in other Mediterranean cities

(Barcelona, Athens, Marseille, Naples) actually suffering important immigration flows are examples of this way of thinking.

On the topic of the relation between criminality and immigration there is an harsh debate in Italy with contradictory results (Barbagli, 1998; Dal Lago, 1999). Some field surveys indicate that Italians' perception of insecurity is fueled by the presence and concentration of illegal migrants, especially those from Africa, the Balkans and the Middle East (Mignella Calvosa, 2004). In November 1998, according to Censis (1999), 35% of Italians were convinced that the area where they were living was more dangerous than in the past and 66% thought than in Italy crimes have increased. A year later, according to Censis (2000), the 75% of Italians was convinced that there was a direct correlation between the presence of immigrants and the growth of criminality. Analysing police data, Bianchi et al. (2008) documented that the size of immigrant population is positively correlated with the incidence of murders, robberies and, to a lesser extent, thefts. By contrast, in a very recent report, Caritas affirms that immigrants have the same criminality rates of the Italians and that in 2008 criminality decreased by 15% in the prefecture of Rome although resident immigrants significantly increased in their number (Caritas, 2010).

Of course, the rapidly expanding immigration became likely one of the most crucial socioeconomic phenomena potentially gripping the Mediterranean cities. While we are not sure that the 'landscape of insecurity' cited earlier is produced (only) by illegal immigrants (Palidda, 2000), the local authorities engaged to manage this relatively novel problem were often found unprepared to solve the related social conflicts. In order to understand the factors which drive the spatial patterns of urban insecurity, the analysis of distribution, type, and severity of urban crime should be integrated with qualitative data collected through interviews, focus groups, and direct observation in significant places of the city (Taylor and Jamieson, 1998). Finally, strategies aimed at mitigating poverty appear as especially effective in preventing urban crime (e.g. Oc and Tiesdell, 1998). The integration of migrants in the urban community and their participation to social and economic activities (e.g. markets, commercial shops, migrants' meeting points, etc.) can also contrast the perceived link between insecurity and immigration. These measures could have also the indirect effect to mitigate social conflicts and racism episodes in the city.

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Figure 1. The nineteen boroughs of Rome (left) and the average distribution of value added in 2003 (Euros *per capita*). CDV indicates the Vatican State.

Figure 1a

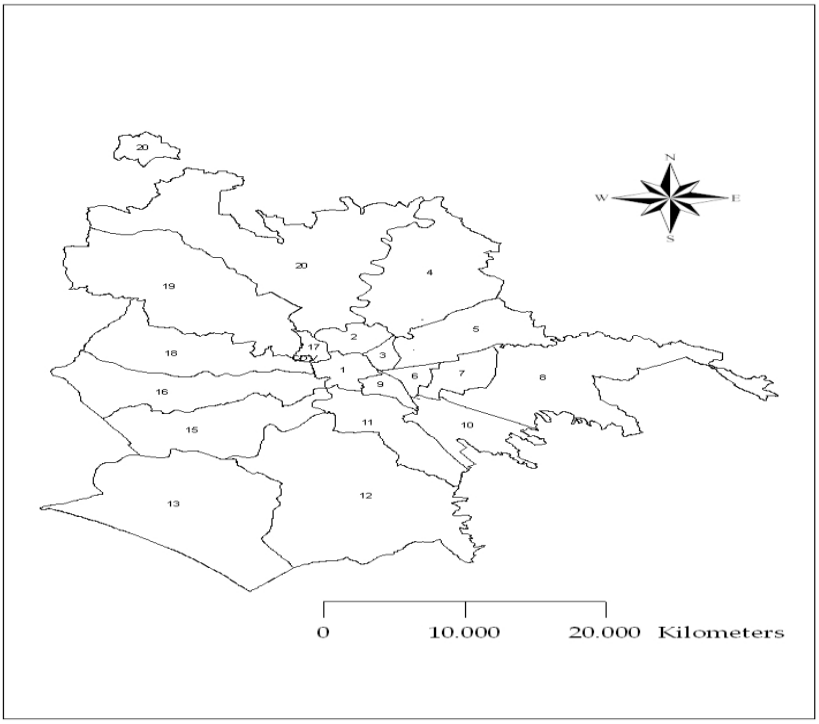

Figure 1b

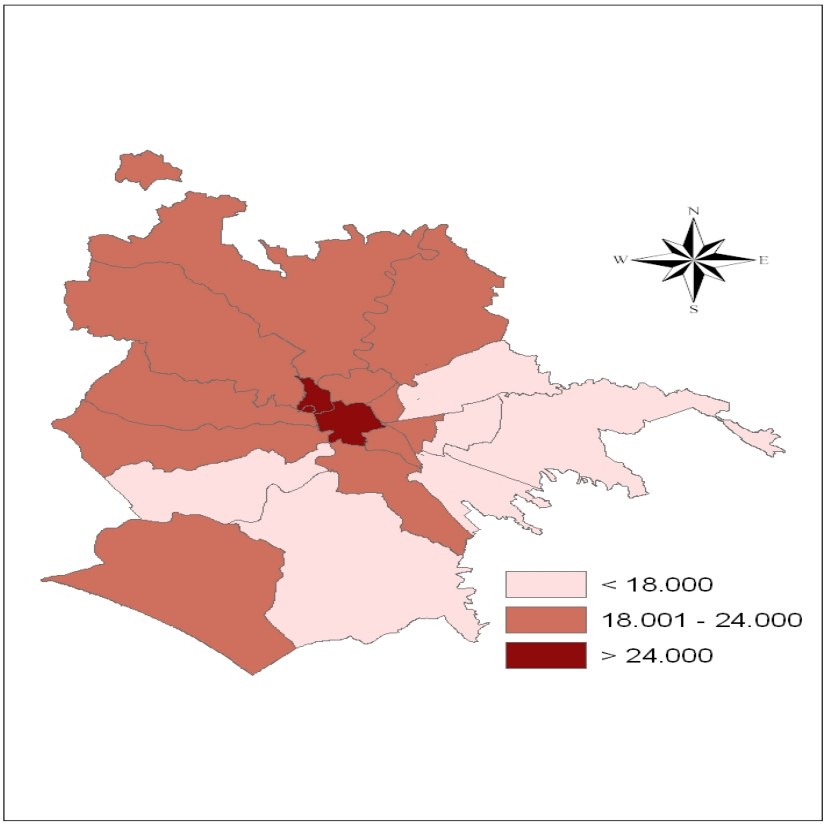

Figure 2. Spatial distribution of the gross crime rate in Rome.

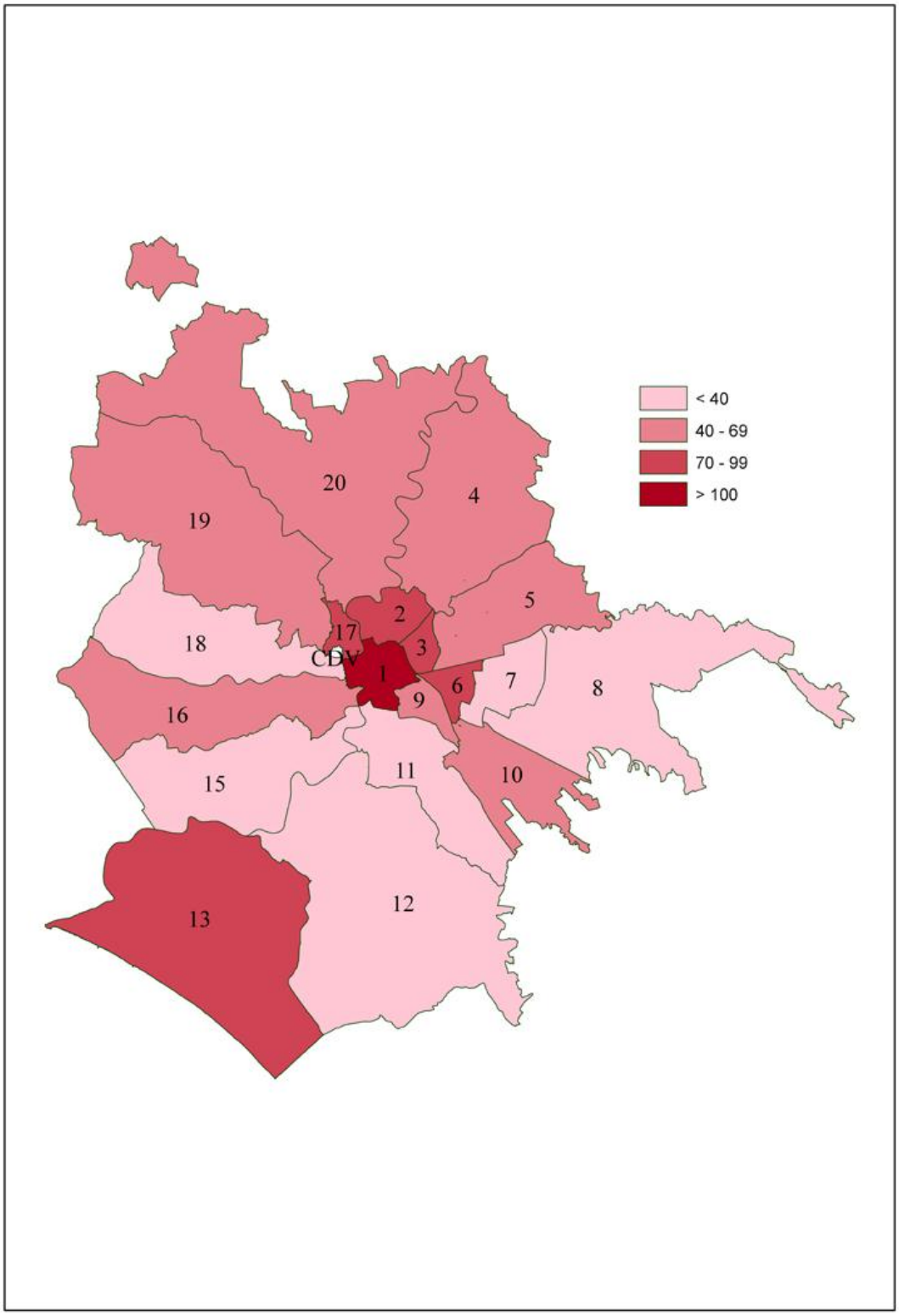

Figure 3. Spatial distribution of some selected crime indicators in the boroughs of Rome

Figure 3a. Violent crimes

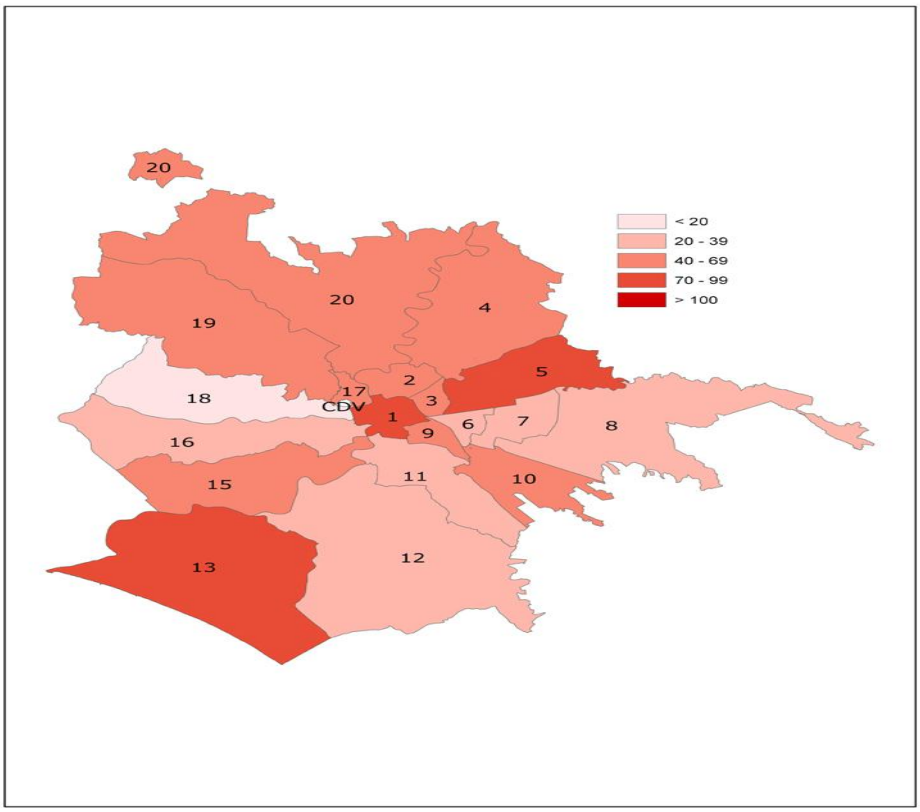

Figure 3b. Thefts

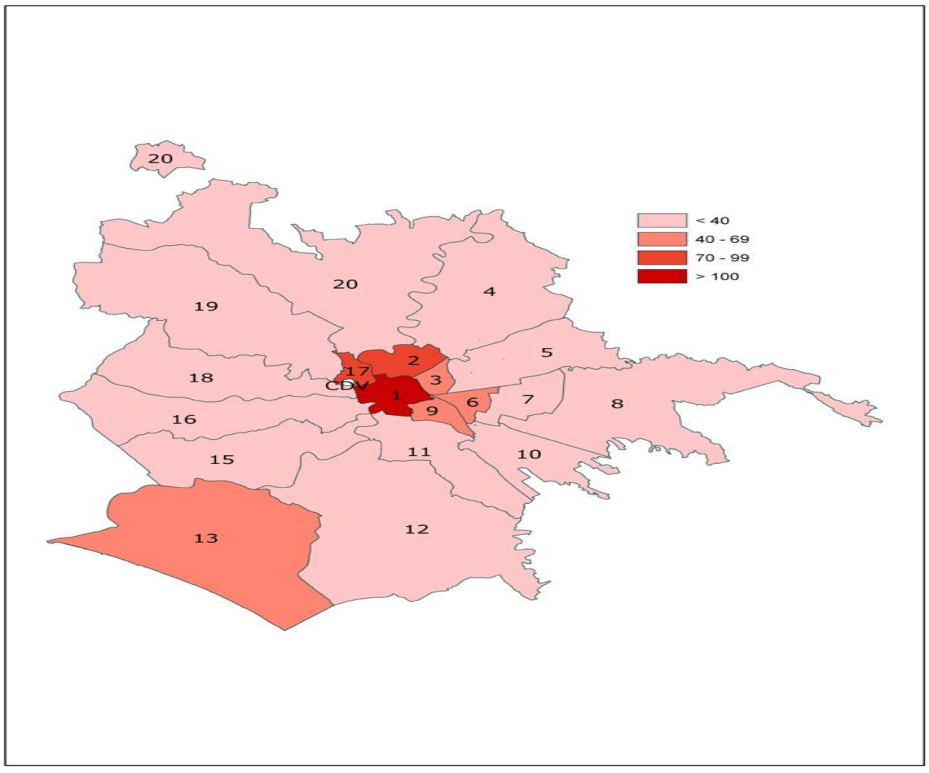

Figure 3c. Robberies

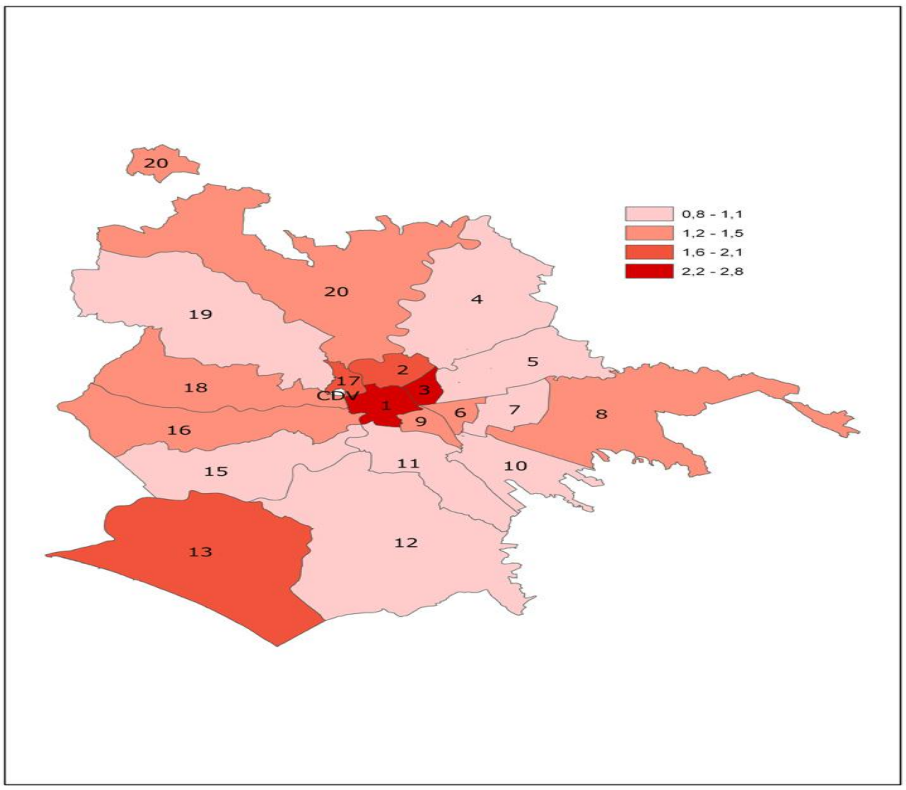

Figure 3d. Production and selling of drugs

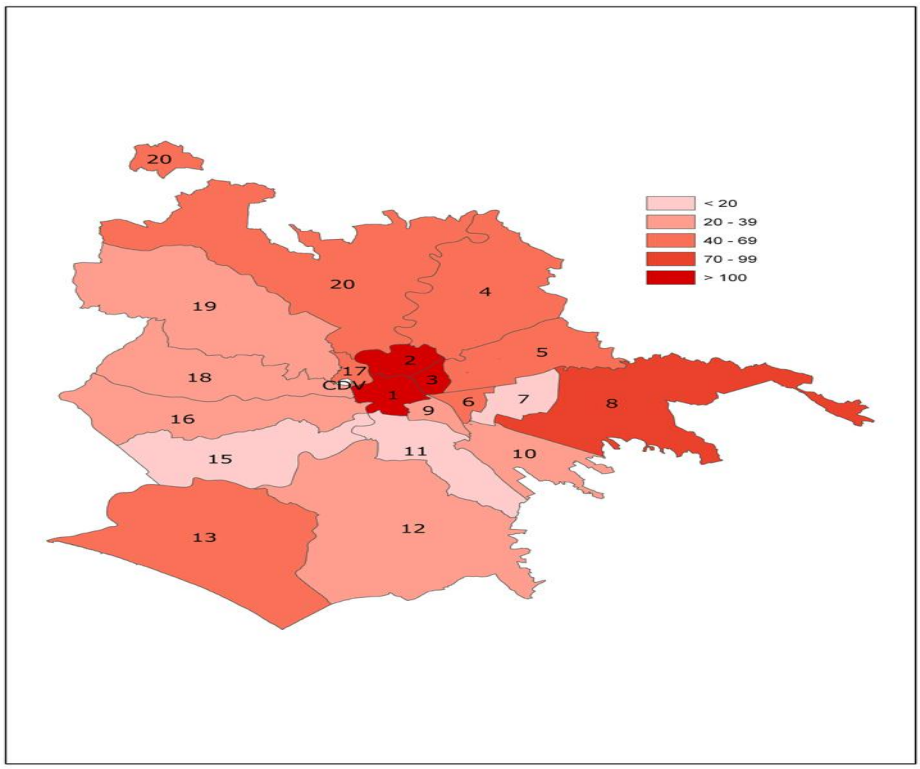

Figure 4. Factor scores indicating the position of Rome boroughs on the factorial plane of the PCA applied to crime indicators

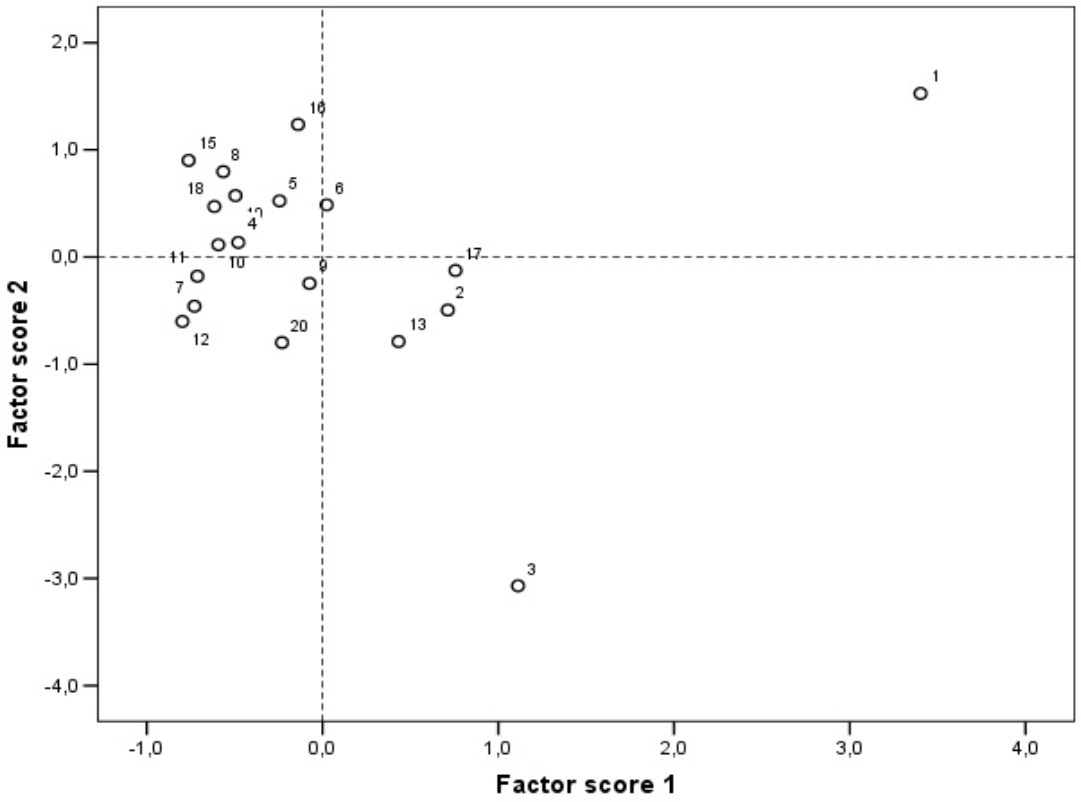

Figure 5. Factor scores indicating the position of Rome boroughs on the factorial plane of the PCA applied to the socio-economic indicators

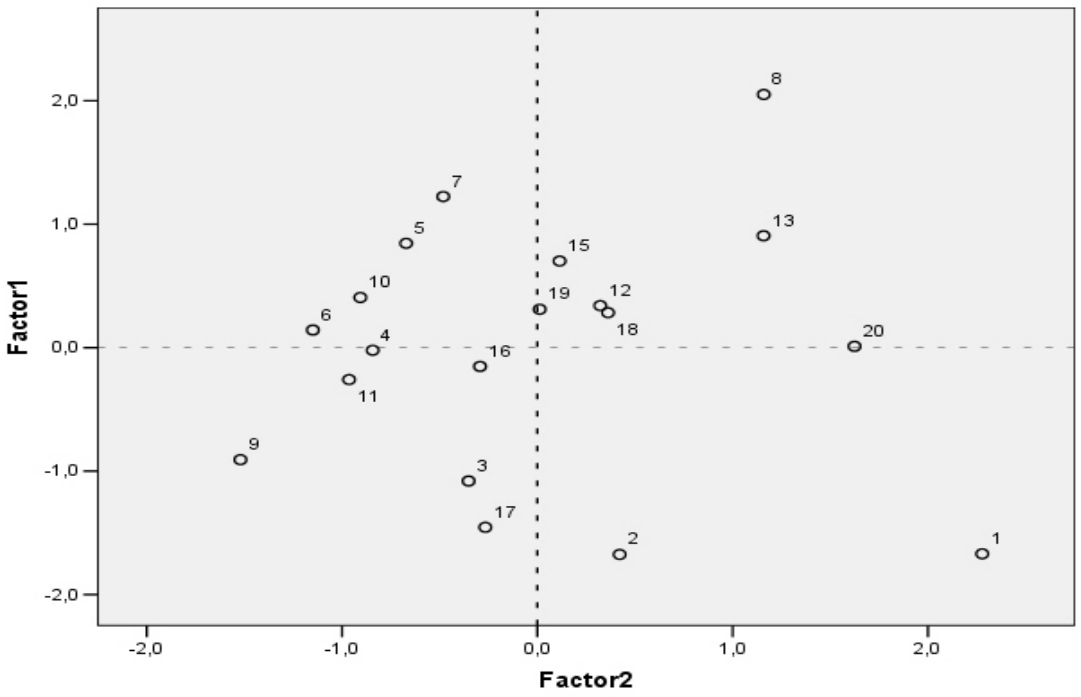

Figure 6. Correlation between the two variables recorded in the field survey by borough (see Table 7)

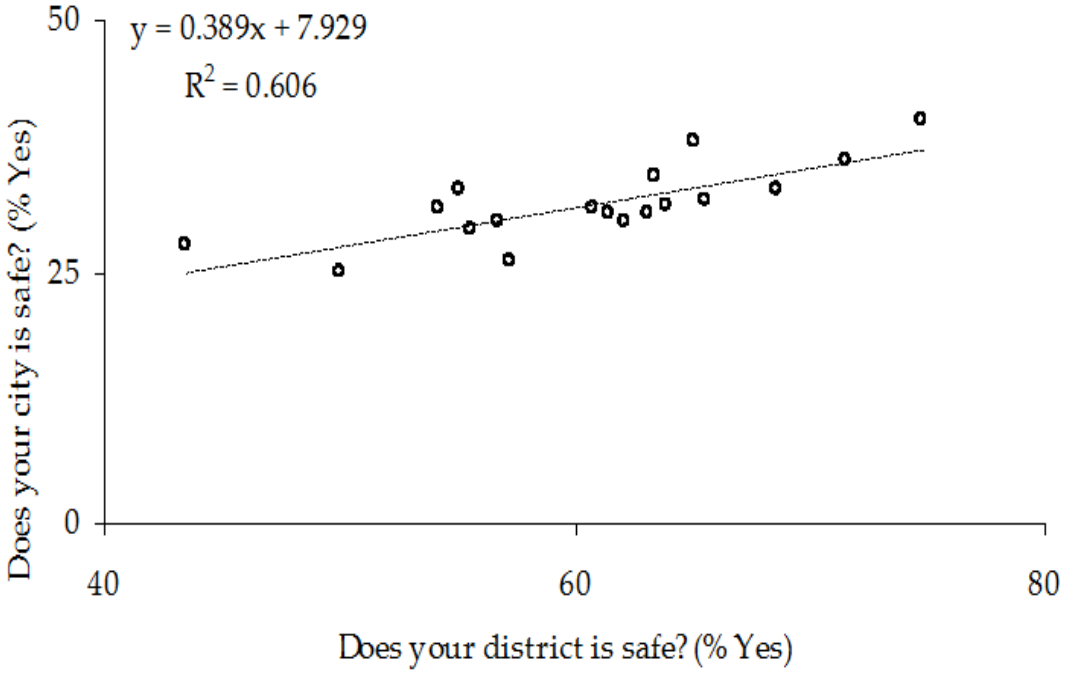

Figure 7. Correlation between the gross crime index and the two variables recorded in the field survey by borough (see Table 7)

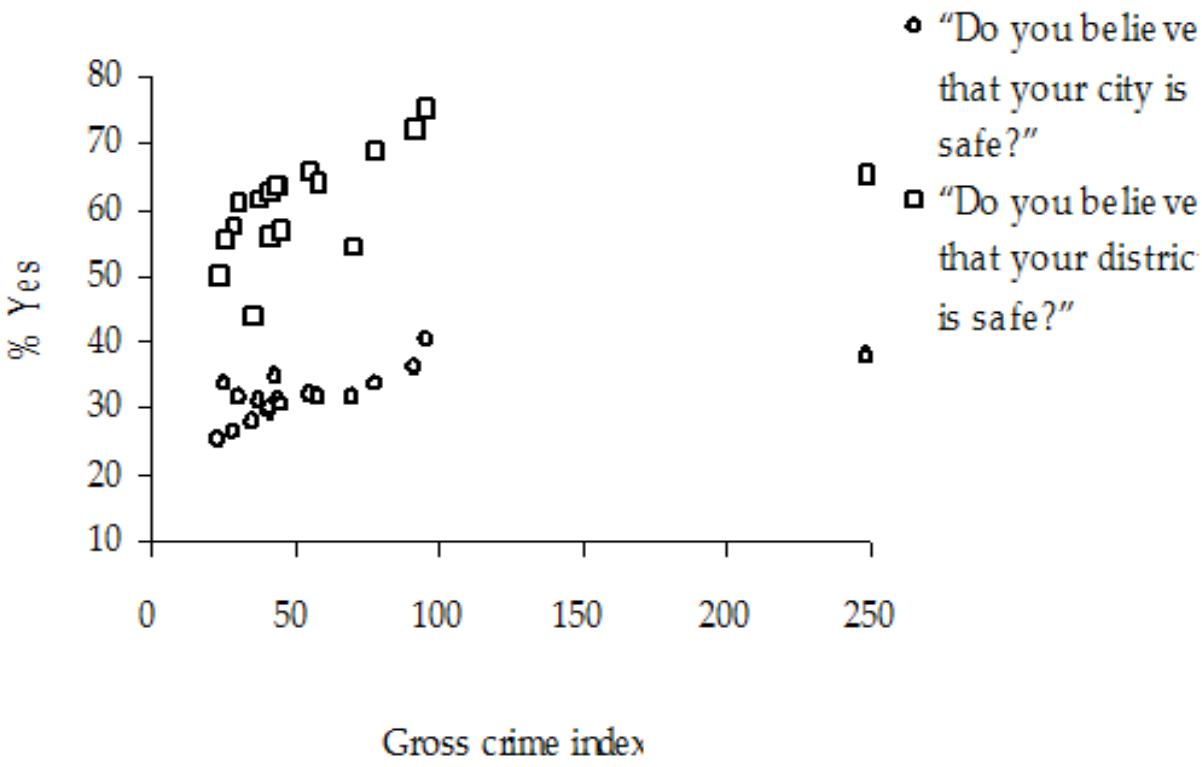

Table 1. Gross crime index and selected crime rates by type and borough in Rome (2001)

Boroughs	Gross crime rate (per 1.000 individuals)	Violent crime rate (per 100.000 in.)	Murders (per 100.000 in.)	Attempted murders (per 100.000 in.)	Aggravated assaults (100.000 in.)	Sexual assaults (per 100.000 in.)	Thefts (per 1.000in.)	Pick-pocketing (per 1.000 in.)	Snatch (per 10.000 in.)	Thefts in house (per 1.000 in.)	Thefts in shop (per 1.000 in.)	Robberies (per 1.000 in.)	Bank robberies (per 10.000 in.)	Post office robberies (per 10.000 in.)	Robberies in jewellers and precious laboratories (per 10.000 in.)	Robberies to engaged couples or street-walker (per 10.000 in.)	Other robberies (per 10.000 in.)	Production and selling of drugs (per 1.000 in.)	Prostitution crimes (per 100.000 in.)
I	249.5	1.2	6.5	5.7	81.6	28.5	208.0	124.8	21.5	6.6	6.0	2.8	1.4	0.3	0.6	0.7	25.4	1.5	21.2
II	96.5	0.4	1.6	3.2	25.7	8.0	76.6	16.0	14.2	7.4	2.6	1.9	1.4	0.2	0.2	0.2	16.8	1.0	19.3
III	78.9	0.8	1.8	8.8	61.7	8.8	64.3	14.3	9.5	5.2	1.8	2.7	1.2	0.0	0.0	0.4	25.6	1.0	28.2
IV	45.6	0.3	0.5	2.0	23.5	5.9	33.4	4.3	7.6	3.2	1.8	1.0	0.7	0.2	0.0	0.1	9.0	0.6	11.3
V	42.6	0.4	1.1	3.8	30.1	7.0	32.3	4.5	10.0	2.4	1.8	1.1	0.4	0.3	0.0	0.5	10.2	0.6	9.7
VI	70.9	0.3	1.5	3.8	19.8	5.3	47.4	7.0	8.3	3.8	2.8	1.5	0.5	0.3	0.2	0.4	13.5	0.6	12.9
VII	24.6	0.2	2.4	2.4	15.0	3.2	20.2	4.1	2.6	2.0	0.9	1.1	0.2	0.0	0.0	0.3	10.4	0.2	14.2
VIII	36.8	0.2	0.5	3.0	14.6	3.0	31.0	4.1	7.6	3.0	1.1	1.2	0.1	0.4	0.1	0.3	11.0	0.7	9.0
IX	56.3	0.4	1.5	0.0	31.6	5.3	48.2	7.9	7.5	5.7	2.6	1.4	0.5	0.1	0.0	0.4	13.4	0.3	15.0
X	46.0	0.4	1.1	3.9	25.9	4.4	35.6	5.8	5.4	2.4	1.0	0.9	0.3	0.1	0.1	0.2	8.1	0.3	9.9
XI	31.8	0.3	0.7	2.9	18.6	5.0	25.8	3.0	4.1	1.7	0.7	0.8	0.6	0.1	0.0	0.4	7.0	0.2	12.9
XII	29.7	0.1	1.2	0.0	8.6	3.7	24.3	1.8	2.8	2.6	0.6	0.9	0.4	0.0	0.1	0.2	8.3	0.3	20.9
XIII	77.4	0.7	2.1	5.6	55.9	6.7	52.7	4.4	7.2	5.3	2.5	1.7	0.4	0.3	0.1	0.3	16.1	0.6	21.0
XV	26.7	0.3	0.6	3.9	19.4	4.5	21.1	2.5	5.1	1.9	0.9	0.9	0.3	0.5	0.1	0.2	8.4	0.2	10.3
XVI	59.4	0.3	2.7	2.7	16.3	3.4	39.4	6.4	19.1	4.1	1.3	1.2	0.7	0.4	0.3	0.1	10.6	0.3	13.6
XVII	92.1	0.6	1.3	0.0	50.5	9.3	72.3	17.9	14.5	5.2	2.8	2.1	1.1	0.0	0.5	0.3	19.4	0.5	17.3
XVIII	38.0	0.1	2.2	2.2	5.9	3.0	31.4	7.1	8.5	3.1	1.3	1.3	0.2	0.1	0.1	0.2	12.1	0.3	8.1
XIX	41.9	0.3	1.1	0.0	22.9	3.9	32.5	4.3	5.4	5.0	2.0	1.0	0.3	0.2	0.2	0.2	9.0	0.3	11.7
XX	44.6	0.3	2.7	3.4	19.7	6.1	31.3	3.6	3.4	5.3	1.4	1.3	0.5	0.1	0.0	0.2	12.5	0.6	17.0
Rome	**58.5**	**0.4**	**1.6**	**2.9**	**26.8**	**6.1**	**44.9**	**10.9**	**8.2**	**3.8**	**1.8**	**1.3**	**0.5**	**0.2**	**0.1**	**0.3**	**12.0**	**0.9**	**14.1**

Table 2. Spearman rank correlation tests applied to the crime indicators considered in this paper

Variables	Violent crime rate	Murders	Attempted murders	Aggravated assaults	Sexual assaults	Thefts	Pickpocketing	Snatch	Thefts in house	Thefts in shop	Robberies	Bank robberies	Post office robberies	Robberies in jewellers	Robberies to engaged couples	Other robberies	Production and selling of drugs	Prostitution crimes
Gross crime rate	**0,803**	0,416	0,328	**0,770**	**0,745**	**0,982**	**0,847**	**0,745**	**0,808**	**0,834**	**0,809**	**0,759**	0,065	0,465	0,228	**0,775**	**0,696**	0,553
Violent crime rate		0,215	0,515	**0,970**	**0,857**	**0,811**	0,649	0,513	0,565	**0,664**	0,593	0,625	0,038	0,170	0,465	0,572	0,511	0,527
Murders			0,204	0,147	0,192	0,359	0,439	0,256	0,541	0,306	0,616	0,297	-0,166	0,222	0,104	0,596	0,202	0,554
Attempted murders				0,427	0,403	0,255	0,155	0,190	0,067	0,113	0,286	0,154	0,368	-0,003	0,358	0,288	0,450	0,180
Aggravated assaults					**0,864**	**0,793**	0,623	0,450	0,580	**0,723**	0,576	0,577	-0,013	0,100	0,471	0,557	0,530	0,503
Sexual assaults						**0,712**	0,536	0,464	0,580	**0,691**	0,607	**0,773**	-0,063	0,086	0,441	0,601	0,617	0,598
Thefts							**0,886**	**0,754**	**0,805**	**0,856**	**0,792**	**0,716**	0,047	0,474	0,253	**0,756**	0,649	0,520
Pickpocketing								**0,830**	**0,658**	**0,782**	**0,804**	0,559	-0,061	0,443	0,318	**0,762**	0,516	0,311
Snatch									0,495	**0,657**	**0,662**	0,570	0,310	0,530	0,200	0,621	0,599	0,117
Thefts in house										**0,799**	**0,817**	0,593	0,002	0,353	0,085	**0,804**	0,647	0,628
Thefts in shop											0,795	0,550	0,152	0,430	0,361	**0,770**	0,629	0,373
Robberies												0,528	-0,027	0,348	0,394	**0,995**	**0,710**	0,576
Bank robberies													-0,090	0,224	0,167	0,515	0,492	0,651
Post office robberies														0,337	-0,051	-0,038	0,205	-0,346
Robberies in jewellers															-0,126	0,308	0,197	0,154
Robberies to engaged couples																0,389	0,282	0,247
Other robberies																	**0,701**	0,588
Production and selling of drugs																		0,362

Table 3. Socio-economic indicators in Rome by borough (2001)

Boroughs	Population density	Average family size	Elderly index	*Per capita* value added	% graduated workers	% population outside primary education	Unemployment index	% highly-qualified workers	% agricultural workers	% employed in the industrial sector	% resident foreign people	% foreign people from Europe	% foreign people from Africa	% foreign people from Asia	% unoccupied dwellings	% rented dwellings	Dwelling size (Rooms *per* dwelling)	Dwelling composition (Resident people *per* room)	Dwelling overcrowding index	% not recycled urban waste	% recycled paper on total waste	% change in green area surface	Per capita water consumption	Surface area (hectares)
I	6730	2.1	242	25 067	27.9	0.3	8.3	17.2	1.3	12.2	18.4	36.5	12.8	33.6	21.3	35.5	4.0	2.1	1.4	1.0	1.1	0.9	104.9	1430
II	8099	2.2	226	27 615	33.0	0.2	7.1	19.0	1.4	11.9	9.7	35.4	10.7	36.8	9.7	23.2	4.7	2.2	1.4	1.8	0.4	-8.7	97.2	1367
III	8398	2.2	243	19 193	27.5	0.4	8.1	14.2	1.2	12.2	6.5	33.9	14.5	32.0	10.4	22.6	4.1	2.2	1.6	2.4	0.4	0.5	94.9	591
IV	1955	2.4	182	21 091	15.8	0.4	11.3	9.5	1.1	14.6	5.3	38.0	13.9	30.7	8.0	35.7	3.9	2.5	1.6	3.5	0.1	21.7	76.0	9782
V	3655	2.6	127	15 367	9.7	0.7	13.0	6.1	1.3	17.4	5.6	40.9	18.3	24.7	6.7	36.4	3.7	2.6	1.7	3.1	0.2	20.5	72.2	4915
VI	16336	2.4	207	19 193	8.5	0.6	12.2	5.4	1.6	17.0	9.6	23.9	19.0	43.1	7.9	25.7	3.5	2.4	1.8	3.0	0.4	-16.7	69.2	792
VII	6018	2.5	146	15 798	6.1	0.8	13.7	4.5	1.6	20.4	9.6	41.7	23.8	20.9	7.6	28.6	3.4	2.5	1.8	2.8	0.2	34.8	67.7	1906
VIII	1645	2.8	92	14 064	4.2	1.0	16.9	4.0	1.8	25.0	9.5	55.2	19.7	15.0	9.6	28.9	3.8	2.8	1.9	3.8	0.7	14.4	60.0	11.336
IX	14947	2.2	243	20 817	17.9	0.3	8.9	9.6	1.0	13.3	7.0	32.2	10.5	35.8	9.6	22.7	3.7	2.2	1.5	2.6	0.1	25.4	78.7	807
X	4589	2.5	158	17 991	8.8	0.5	11.4	6.2	1.3	16.4	5.2	40.3	14.1	25.9	6.4	33.6	3.8	2.5	1.7	2.1	0.2	-13.7	71.1	3868
XI	2735	2.3	211	23 263	18.2	0.3	9.1	8.7	1.3	14.2	7.0	40.2	10.3	30.5	7.8	30.8	4.0	2.4	1.8	3.0	0.1	73.9	78.6	4729
XII	813	2.6	110	17 938	18.2	0.4	9.6	8.7	1.3	15.6	6.4	48.6	11.3	22.6	7.9	24.3	4.4	2.7	1.7	4.0	0.4	29.7	81.7	18.317
XIII	1156	2.6	107	19 194	10.2	0.6	12.4	6.6	1.6	17.7	7.2	51.1	18.7	16.5	12.5	25.7	3.9	2.6	1.7	4.9	0.6	0.6	74.1	15.064
XV	1956	2.5	159	16 788	9.8	0.7	11.9	6.2	1.7	17.6	8.5	43.2	14.1	30.2	9.2	31.3	3.6	2.5	1.8	3.8	0.4	-0.4	74.5	7087
XVI	1840	2.4	198	18 031	18.0	0.5	8.9	11.0	1.3	14.3	8.6	40.7	11.8	27.2	9.6	24.7	3.9	2.4	1.7	3.2	0.1	2.9	78.5	7312
XVII	11111	2.2	267	24 895	26.5	0.2	7.4	17.6	1.2	12.2	8.1	38.1	8.4	32.0	9.8	28.3	4.2	2.2	1.5	2.3	0.3	0.0	93.5	561
XVIII	1787	2.5	172	18 369	14.5	0.6	11.4	9.0	1.8	16.1	11.4	41.1	12.3	27.1	7.6	24.4	3.8	2.5	1.6	2.7	0.4	2.7	73.9	6867
XIX	1226	2.5	153	18 369	14.7	0.5	10.9	8.8	1.8	16.3	8.3	34.2	14.3	30.9	10.0	23.4	3.9	2.5	1.7	3.6	0.2	17.6	71.5	13.128
XX	677	2.5	131	19 647	20.8	0.6	9.8	14.7	2.0	17.2	13.9	36.9	13.8	30.9	11.9	24.5	4.3	2.5	1.6	5.9	0.4	15.0	88.1	18.671

Table 4. Results of the PCA applied to the crime indicators: the component matrix

Variable	Component			
	1	2	3	4
Gross crime rate	0.973	0.189	-0.026	-0.062
Violent crime rate	0.926	-0.112	0.188	-0.014
Murders	0.787	0.196	0.022	-0.228
Attempted murders	0.469	-0.345	0.690	0.315
Aggravated assaults	0.888	-0.198	0.154	-0.031
Sexual assaults	0.939	0.169	0.098	-0.197
Thefts	0.967	0.186	-0.022	-0.111
Pickpocketing	0.892	0.305	0.069	-0.243
Snatch	0.755	0.350	-0.218	0.330
Thefts in house	0.714	-0.180	-0.428	0.258
Thefts in shop	0.911	0.229	-0.072	-0.074
Robberies	0.913	-0.299	-0.051	0.105
Bank robberies	0.803	-0.221	-0.297	0.196
Post office robberies	0.053	0.644	0.409	0.585
Robberies in jewelers	0.695	0.464	-0.373	0.021
Robberies to engaged couples or street-walker	0.660	0.046	0.433	-0.424
Other robberies	0.895	-0.337	-0.033	0.091
Production and selling of drugs	0.875	-0.086	0.137	0.184
Prostitution crimes	0.620	-0.663	-0.124	0.019

Table 5. Results of the PCA applied to the socio-economic indicators: the component matrix

Variable	Component			
	1	2	3	4
Population density	-0.50	-0.44	0.58	0.13
Average family size	0.94	0.15	-0.23	0.03
Elderly index	-0.88	-0.29	0.24	-0.05
Per capita value added	-0.88	0.11	-0.08	-0.06
% graduated workers	-0.92	0.23	-0.24	0.06
% people outside primary education	0.91	0.15	0.31	0.10
Unemployment rate	0.93	0.04	0.28	-0.10
% highly-qualified workers	-0.89	0.34	-0.15	0.08
% agricultural workers	0.55	0.54	0.14	0.51
% employed in the industrial sector	0.93	0.16	0.17	0.04
% resident foreign people	-0.26	0.74	0.44	0.09
% foreign people from Europe on total foreigners	0.60	0.41	-0.45	-0.36
% foreign people from Africa on total foreigners	0.72	0.05	0.48	-0.02
% foreign people from Asia on total foreigners	-0.72	-0.30	0.34	0.33
% unoccupied dwellings	-0.44	0.73	0.29	-0.18
% rented dwellings	0.16	-0.01	0.18	-0.81
Dwelling size	-0.59	0.37	-0.61	0.14
Dwelling composition	0.94	0.13	-0.22	0.03
Dwelling overcrowding index	0.84	-0.24	-0.02	0.07
% not recycled urban waste	0.56	0.22	-0.39	0.46
% recycled paper waste type: paper	-0.09	0.83	0.38	-0.18
% change in green area surface	0.18	-0.21	-0.45	-0.24
Per capita water consumption	-0.89	0.36	-0.09	-0.07

Table 6. Spearman rank correlation coefficients between the scores of each borough on the main axes of 'socio-economic' PCA and some selected crime indicators

(n = 19 for all comparisons; * indicates significance at $p < 0.05$ after Bonferroni correction)

Crime type	Factor 1	Factor 2
Gross crime rate	-0.674*	0.102
Violent crime rate	-0.480	-0.014
Murders	-0.311	0.345
Attempted murders	0.062	0.207
Aggravated assaults	-0.435	-0.068
Sexual assaults	-0.596	0.074
Thefts	-0.672*	0.054
Pickpocketing	-0.644*	-0.023
Snatch	-0.538	0.115
Thefts in house	-0.607	0.372
Thefts in shop	-0.526	0.065
Robberies	-0.509	0.328
Bank robberies	-0.891*	-0.031
Post office robberies	0.239	0.219
Robberies in jewellers and precious laboratories	-0.267	0.374
Robberies to engaged couples or street-walker	-0.106	-0.174
Other robberies	-0.491	0.333
Production and selling of drugs	-0.324	0.412
Prostitution crimes	-0.514	0.252

Table 7. Results of a survey on the issue of urban security among Roman citizens by borough

(see text for details)

# borough	"Do you believe that your district is safe?" (% Yes)	"Do you believe that your city is safe?" (% Yes)
I	65.1	37.7
II	74.8	40.0
III	68.7	33.1
IV	63.2	30.6
V	55.6	29.1
VI	54.3	31.2
VII	50.1	25.0
VIII	43.5	27.4
IX	65.6	31.9
X	56.8	30.0
XI	60.8	31.2
XII	57.3	26.0
XV	55.2	33.1
XVI	64.0	31.5
XVII	71.6	36.1
XVIII	61.5	30.8
XIX	62.2	29.8
XX	63.5	34.3
Rome	**61.5**	**31.9**

Table 8. Correlation between the crime indicators used in this paper and the two variables recorded in the field survey by borough (see text and Table 7 for details)

Variable	Safe borough (Yes%)	Safe city (Yes %)
Gross crime rate	0.43	0.65
Violent crime rate	0.61	0.87
Murders	0.82	0.66
Attempted murders	0.58	0.34
Aggravated assaults	0.58	0.34
Sexual assaults	0.39	0.32
Thefts	0.80	0.97
Pickpocketing	0.97	0.97
Snatch	0.75	0.67
Thefts in house	0.47	0.36
Thefts in shop	0.70	0.71
Robberies	0.74	0.76
Bank robberies	0.65	0.30
Post office robberies	-0.12	-0.14
Robberies in jewellers	0.55	0.19
Robberies to engaged couples or street-walker	0.02	0.30
Other robberies	0.51	0.35
Production and selling of drugs	0.56	0.31
Prostitution crimes	0.55	0.73

Cooperation on Stocks Recover

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***Abstract* - The study of cooperation shows that often it brings gains to the agents. In this study it is shown that cooperation is very interesting when exploiting marine live resources. Several kinds of models have been used to show the advantages of cooperation in fisheries (see Munro, 2002; Miller and Munro, 2002; Clark, 1980; or Levhari and Mirman, 1980, for example). In this study, a general model for fisheries is presented and a Cournot-Nash model supported on the variable fishing effort is introduced, both showing that cooperation is useful.**
Keywords— *Fisheries, Cooperation, Cournot-Nash model, Stocks recover.*

1. Introduction

The study of commons is very important when intending to analyze the consequences of human behavior in the exploitation of Earth resources. Hardin's publication of "the tragedy of the commons" (Hardin, 1968) was a reference for the problems that traditionally occur in the natural resources area. The essence of the problem is that resources are over-exploited because each agent aims to have the maximum benefits in line with the generalized selfish human behavior.

Hardin proposed several measures intending to preserve resources from over-exploitation. He proposed, for example, the privatization of resources or the implementation of coercive measures. Of course it is important to implement several rules to avoid tragedies and the cooperation among agents is an important instrument to reach this aim. This means that if there is cooperation – among all the agents who exploit the resource and the agents who rule or coordinate resources exploitation - the given resource is prone to be well managed, to be well regulated and to be well preserved. This may allow higher prices in the market for a given resource and higher levels of rents for fishers through low catches -or a reduced exploitation of the resource, whichever it is.

This paper intends to discuss the advantages of cooperation and how cooperation and regulation may contribute to have high levels of stocks and to have high rents for fishers. After giving an overview, showing why cooperation seems to be important to bring up good results to fishing common pools, a presentation of the bio-economic modeling, as it has been presented traditionally, is outlined. Then, a Cournot-Nash model is presented to explain the competing agents' behavior and the role of cooperation in fisheries. It is possible to see that cooperation brings up procedures that allow the preservation of species and stocks recover. Finally, some concluding remarks are over lighted from the study.

2. The cooperation as an interesting way to manage resources

In order to find out solutions to the problem of resource management, cooperation has been seen as an interesting way to reach good results in the exploitation of the commons. Some interesting patterns of human cooperation are exemplified in the literature on institutions for managing the commons (Richerson, Boyd and Paccioti, 2002). Several authors have been studying cooperation on fishing area, as well. It is the case of Gronbaek (2000), who studies a cooperative and a non-cooperative solution in the fishing field and formalizes mathematically a sustainable cooperative solution. Munro (2002) presents, himself, some interesting cases of cooperation on fishing area. Miller and Munro (2002) show that, in general, cooperation is important and that non-cooperation in fisheries usually leads to the overexploitation of the resources.

Clark (1980) and Levhari and Mirman (1980) have studied non-cooperative fishing games. Their studies are supported in different hypotheses and methodologies but they reach similar conclusions. They show that if each country tries to maximize its own welfare, taking into account the actions of the other country, a long term equilibrium can be achieved. This equilibrium will guarantee the

maximization of the present value of the net economic revenue from the fishery over time and will keep the renewable resource stock at the optimal steady state biomass. Both papers show that the common bionomic equilibrium will occur at a lower stock than the one that would be optimal if the two countries form a cooperative venture (see Hang, 2003).

Clark (1980) uses a linear control model to describe fisheries confined to the EEZ - European Economic Zone - waters of a single coastal state and then he assumes that there are two players in the game, sharing the fisheries of a single fish stock. Both trying to exploit the maximum possible part of the stock because they have no restrictions to access it. Consequently, the exploitation by each one of the agents will affect the available part of the stock that will remain in the sea and this will affect the amount of fish that its competitor will have available. Clark shows that non-cooperative feedback equilibrium is discontinuous in the control variable -fishing effort- and that only the most efficient country harvests in the equilibrium (see Hang, 2003).

Levhari and Mirman (1980) use a Cournot model to compare the competitive and the collusion solutions to identify the advantages of cooperation in resources exploitation. They show that the Cournot-Nash equilibrium leads to greater consumption as a function of the size of the fish population and to a smaller steady state consumption (see Hang, 2003). It is interesting to evidence that this methodological approach, which is not much used as the dynamic games proposal of Clark and followers, is rehabilitated in this paper. The reasons will be presented in this paper.

The conservation of natural resources is an important issue that is relevant to study. Besides, when some agents propose themselves not to exploit a resource because they are worried with resources preservation, if one agent considers that there is an opportunity to gain advantages to exploit the resources that another agent has left and he does it, the tragedy may come. The agent that is concerned about the future has lost the rents for not exploiting the resource and, as a consequence, the other agent has won the short run rents for exploiting it.

This problem represents very well the traditional formal issue "Dilemma of the Prisoner" that is relevant in the Game Theory analysis (Filipe, 2007; Filipe, Coelho & Ferreira, 2005). This problem is posed in the Game Theory for situations in which the two players in the game have dominant strategies, what makes that the solution of the game is a dominant strategies' equilibrium. This equilibrium is stable and the players will not change their choices. What is a problem is that this kind of solution implies a total payoff that is under the result one that the players could have if they had some form of cooperation between them. In these situations, the players will choose the dominant strategy (which in the case of the natural resources is always the strategy of non conservation) and they will not have incentives to use efficiently and conserve the resource. The players are compelled to switch this strategy because they are functioning in competition conditions. So, this puts the players in a situation that represents a dilemma with ethical boundaries. By one side, the fisherman really thinks that is important to have a proper management policy for the use of the resource in the long term but by the other side he is compelled to have an egoistic and myopic view of the resource use and exploit it too much compared with the ideal inter-temporal production level.

The problem of over-fishing has long been claiming for good practices coming from international cooperation and coming from a preserving approach on the processes of decision making of resource management institutions. This may be some kind of a contribution to solve some of the multiple problems in the area of Commons. So, to solve the problem of maintaining the biodiversity, the preservation and related ethical issues in this area it is necessary to pose questions about how to use environment and Earth resources and how to treat other species, plant or animal. Cooperation has an important role in this subject.

3. The advantages of cooperation in a general model for fisheries

The purpose is to study the advantages of cooperation behavior. The presentation of this section allows to get a theoretical view for the bio-economic analysis of fishing agents.

In order to see how an optimal control problem may be important to analyze such a situation, as shortly as possible this problem in described this section.

First, assume asymmetric competitors with different fishing costs and that there is no cooperation.

The resource dynamics is given by the following differential equation (see, for example, Arnason (1990), Conrad and Clark (1987), Munro (1979)):

$$\frac{dx}{dt} = F(x) - h_1(t) - h_2(t), x(0) = x_0, t \in [0, \infty) \quad (1).$$

The variable x $(x \geq 0)$ is the state variable that denotes the biomass - fishery resource measured in terms of weight - $x(t) \in X \subset R_+$. X is the state space. $F(x(t))$ is the stock growth function. $F(x(t))$ is assumed to be a continuous function, concave in x, and so $F(0) = F(K) = 0$ for some $K > 0$ and for $F(x(t)) > 0$, $x(t) \in (0, K)$. The stock representing K is the carrying capacity of the resource.

Also:

$$h_i(t) = q_i E_i(t) x(t) \quad (2).$$

This equation represents the standard Schaefer harvest function. In the equation, q_i represents the "catch ability coefficient" of player i and E_i its fishing effort. This equation shows the relationship between fishing effort and catches of player i. If it is assumed that $q = 1$, so:

$$\pi(x, E_i) = (p_i x - c_i) E \quad (3).$$

Each player sells his own fished resource at a constant price p_i and supports the costs in direct proportion to his fishing effort and it is possible that $C(E_i(t)) = c_i E_i(t)$. C represents the global cost and c_i is the unit cost of fishing effort to the player i. So, player i will attempt to maximize the present value of the net economic revenue from the fishery over time:

$$PV_i(E_1, E_2) = \int_0^\infty e^{-\delta t} \pi_i(x, E_i) dt, i = 1,2$$

subject to

$$\frac{dx}{dt} = F(x(t)) - q_1 E_1(t) x(t) - q_2 E_2(t) x(t), \quad (4).$$
$$x(0) = x_0, t \in [0, \infty)$$

The variable E is defined according $0 \leq E_i(t) \leq E_i^{\max}$ and $\delta > 0$ is the player i discount rate. Both players may face different costs, prices and fishing technologies.

This optimal control (linear) problem, with *x(t)* as the state variable and E(t) as the control variable, allows to conclude that there exists an unique optimal solution and an optimal steady state biomass x^*. This solution is given by the equation:

$$\delta = F'(x^*) - \frac{c'(x^*) F(x^*)}{p - c(x^*)} \quad (5)$$

This equation works as a resource investment rule. It states, in effect, that an agent should invest in the resource up to the point that the yield on the marginal investment in the resource (RHS of the equation) is equal to the social rate of discount.

Besides, if the vessel capital employed in harvesting the resource is perfectly malleable, the optimal approach path to x^* is the most rapid one. In fact, in terms of the variable *h(t)*, the following solution holds:

$$h^*(t) = F(x^*), \text{ if } x = x^*;$$
$$h^*(t) = h^{\max}, \text{ if } x > x^* \quad (6)$$
$$\text{and } h^*(t) = 0, \text{ if } x < x^*$$

If the capital employed is not perfectly malleable, or if the appropriate optimal control model is non-linear (e.g. because the demand for fish exhibits finite elasticity), the most rapid approach path is no longer optimal (see Miller and Munro, 2002).

Equation (5) gives the optimal solution when there is a problem for just one single state. If there are two players (states), both competing for the same fishing stock, the solution (Clark, 1980) will be determined by:

$$h_1^*(t) = \begin{cases} h_1^{\max} & if \quad x(t) > \min(x_1^*, x_2^\infty) \\ F(x) & if \quad x(t) = \min(x_1^*, x_2^\infty) \\ 0 & if \quad x(t) < \min(x_1^*, x_2^\infty) \end{cases} \quad (7),$$

$$h_2^*(t) = \begin{cases} h_2^{\max} & if \quad x(t) > x_2^\infty \\ 0 & if \quad x(t) \leq x_2^\infty \end{cases} \quad (8).$$

This means that when the players act independently, the Nash non-cooperative feed-back solution is such that the resource will be depleted in a most rapid approach manner until the bionomic level x_2^{∞} has been reached. That is, in the two players' game, the shared stock resource can be subject to overexploitation if an agreement cannot be achieved between the two players.

The cooperation appears as a way to overcome the consequences of negative externalities arising from the exploitation of the resource. In Filipe (2006), it is shown that in some situations cooperation is not necessary or indispensable. However, in general, the non-cooperative agents' behavior of leads to sub-optimal solutions and, from the society point of view, a better solution would be reached through a cooperative behavior.

4. Cournot-Nash model for fisheries

Besides the optimal control problem we have seen, we may have an interesting model based on the Cournot oligopoly model that allows us to conclude that cooperation brings very interesting results when we intend to preserve species and that cooperation improve rents for fishers. In fact, the Cournot-Nash model we implemented is a simple model and it has the big advantage of being easily understood by the stakeholders of fishing sector. This model shows the disadvantages of non-cooperation. An extension of the model shows, as well, that cooperation between agents allows better results by improving their situation and the levels of fish stocks.

Considering the Cournot model and integrating Nash equilibrium concept, usually used in theory of games and considering yet fishing effort, it is possible to study the issue of efficiency and overcapitalization in fisheries in a Nation's waters (see Filipe, 2006).

Captures of this species are the quantities (q) used in the traditional Cournot Model. In the usual fishing theories, this variable, *quantities*, has a formal relationship with fishing effort. In this model, this variable (*quantities)* is replaced by another variable, related to that one, precisely the *fishing effort (E).*

So, the usual equations

$$\pi_i (q_1; q_2) = RT_i - CT_i, \text{ i=1,2} \quad (9)$$

are replaced in the model by the equations

$$\pi_i (E_1; E_2) = RT_i - CT_i, \text{ i=1,2; } q_i = f(E_i;X); \quad (10)$$

E_i is the fishing effort used by FP_i *(FP* are the Fishing Producers) and *X* is the biomass level for the specie.

The Cournot model and the consequent Cournot-Nash equilibrium allow to analyze the contribution of cooperation for the preservation of stocks and to analyze its contribution for the stabilization of fishers' rents (Filipe, 2006).

With the maximization of aggregate fishing effort it is expected to reach a lower level than the sum of the reached levels for each individual solution. This is consistent with benefits expected for fishing producers, because fishing costs are expected to be lower. As an additional result, it is expected that the market price would be higher and the aggregate rent would be higher, as well. Besides, as the aggregate fishing effort is expected to be lower, it is expectable that fishers will control catches as well, and consequently, also to get a stock's management more compatible with conservative objectives. These conclusions are the expected results from the usual analysis of Cournot and cartel models (Filipe, 2006).

These conclusions permit to confirm evidences that cooperation is an important factor for the preservation of this specie and it is important to keep high fisher's rents levels. Besides the political reasons, fishers may promote some measures to reduce catches and to organize markets, preserving species for the future generations and protecting fishing present interests. Fishers may manage catches in order to control the activity of fleets and in order to control fishing effort. Consequently, levels for catches may decrease and species' stocks may be well managed. Stocks may be improved and fishers' rents may benefit with this kind of management. In addition, costs may decrease because producers may adjust their production capacity to the required supplies to match the demand of fishing product in the market.

These behaviors represent a genuine form of cooperation.

5. Concluding Remarks

The analysis for fisheries permits the opportunity of studying the role of regulation and cooperation on stocks recovery.

The main conclusions of the paper are the following:

First, cooperation contributes to regulate catches. It seems a good way to support high prices and high rents for fishers and to contribute to preserve stocks. The study confirms these evidences

and shows that, even for higher catches, higher levels for stocks could be supported, as well.

This analysis shows that cooperation can be well understood by the stakeholders of the fishing sector and it proves that there are great benefits, through just a simple way of managing fisheries.

Second, the Cournot-Nash model used to analyze this situation has evident advantages. This model contributes for a better understanding of fishing problems. It seems that this study is very useful for authorities to plan and to rule fishing and for a good communication between national and local institutions of the fishing sector. This general model is easily understood by the stakeholders of the fishing sector.

It is a very simple model that can be well applied by the public decision-makers and it seems to be well adapted to fishing realities. The model is very flexible, adjustable and appropriate to analyze any species since one can adjust it to the available data for the specie object of study. It is very relevant for situations in which it is necessary urgent adjustments for consumption or production.

The flexibility of the model allows us to shape it according to the available information. However, it is necessary to have a minimum of information for variables such as stocks, fishing effort, catches or costs. Besides, this study does not include the analysis of any problems emerged from offers made by foreign fleets.

This model gives to the cooperation a central place in the context of management of a living resource, either in exploitation field or in the market for the resource studied.

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The Impact of Information and Communication Technology on Banks' Performance and Customer Service Delivery in the Banking Industry

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Abstract **- Information and communication technology (ICT) has become the heart of banking sector, while banking industry is the heart of every robust economy. If it collapses so will the economy. This is absolutely evident from current recession in European banks crises, and in turn. The effect of globalization, competition and innovation in the banking industry by its providers to offer their services makes essential the understanding of how various aspects of consumer behaviour affect the innovation and respond to customer service delivery. Within this context this paper has considered a critical literature review of previous researchers with the objective to examine the impact of Information and Communication Technology on banks performance and customer service delivery. This paper also makes of a critical review of peer reviewed, scholarly and organizational literature regarding the impact of ICT on banks' performance to examine if banks have successfully achieved effective customer's service delivery, by providing high level of customer service through online delivery channel, besides operating cost minimization and revenue maximization.**

Keywords **-** *Banking Industry, ICT, Online Banking, Customer Service delivery and Bank's performance.*

1. Introduction

Information and communication technology (ICT) has in particular brought a complete paradigm shift on the bank's performance and on the customer service delivery in the banking industry. In a bid to catch up with global development, improve the quality of customer service delivery, and reduce transaction cost, banks have invested heavily in ICT, and have widely adopted ICT networks for delivering a wide range of value added products and services. The ICT development has a significant effect on development of more flexible and user friendly banking services. In this context one of the objectives of this paper is to examine the relevant literature to assess to what previous researchers have found about the impact of Information Technology on bank's performance and customer service delivery after adoption of information technology.

Customer satisfaction and customer service delivery is a key parameter for banks to ascertain how effectively the web furthers their objectives of customer acquisition, retention and increased share of wallet. The research on the impact of ICT on bank's performance and customer service delivery in the banking industry have been broad. However, few areas, with consumer perspective, are left with less exploratory debate.

Today, information and communication technology has become the heart of banking sector, while banking industry is the heart of every robust economy. If it collapses so will the economy. It is absolutely evident from the current recession, in European banks' crises, and in turn. ICT has created a new infrastructure for the world economy to become truly global and also provided the users of new technology a competitive advantage over their rivals. Electronic banking system has become the main technology driven revolution in conducting financial transactions. However, banks have made huge investments in telecommunication and electronic systems, users have also been validated to accept electronic banking system as useful and easy to use (Adesina and Ayo, 2010).

Castells (2001) reveals that, now transactions worth billions of dollars can only take place in seconds in the electronic circuit throughout the globe by pressing a single butting. Although, ICT has revolutionized the way of living as well as conducting businesses and study of Banking industry has received increased attention over the last decade, it continues to pose challenges for marketers and academic alike. According to Loonam *et al* (2008), ICT advancements, globalization, competition and changing social trends such as heightened customer proactivness and increased preferences for convenience have caused intense restructuring of the banking industry.

2. Theoretical Background

Apparently, to identify and examine the impact of ICT on bank's performance and customer service delivery, the researcher exploded various articles/journals, relevant literature and existing practice of Electronic banking. In today's business, competition, deregulation and globalization have compelled Banks to offer service 24 hours around the globe, whereas the significance drawback, on the other hand, lies in its inconvenience and security factors. However, both these factors have a significant and profound impact on banks' performance and customer service deliver. The relationship that revolves between ICT expenditures, bank's performance delivery is conditional upon the extent of network effects. If the networks are low, ICT is likely to:

- Reduce payroll expenses.
- Increase market share.
- Increase revenue and profit.

Furthermore, in a broader perspective, ICT, deregulation and globalization in the banking industry could reduce the income streams of banks and thus the strategic responses of the banks, particularly the trend towards internal cost cutting, mergers and accusations are likely to change the dynamics of the banking industry. This paper seeks to determine if banks have earned higher income and delivered a high quality service than in traditional way. The main issues that can prevent consumers positively include the convenience aspect of the service, ease of use and its compatibility with their lifestyle.

3. Role of ICT in the Banking Industry

Apparently, there are always potentials of crisis which make the bank endure an insufficiency; advanced ICT supported by a superior mechanism control is required to make certain that ICT has achieved the required processes insufficiency; thus, advanced information system supported by a superior mechanism control is required to make certain that ICT has achieved the required processes. A review of some related literatures reveals that ICT may essentially affect negatively banks efficiency and may reduce productivity. This notion was noted by Solow (1987), "you can see the computer age everywhere these days, but in the productivity statistics".

However, since 1970s to the time Solow was claiming that there was a huge decelerating in growth as the technologies were becoming ubiquitous. On the same vein, the paradox has been defined by Turban, et al. (2008) as the "discrepancy between measures of investment in ICT and measures of output at the national level". ICT has been one of the most essential dynamic factors relating all efforts; it cannot improve banks' earnings. This was revealled in an extensive survey conducted in USA for the period of 1989-1997 by Shu and Strassmann (2005)

Conversely, there are various literatures that debunk Solow's claiming in totality and approve the positive impacts of Information and Communication Technology expenses to business value. In a comprehensive research conducted by Saloner and Shpard (1995) in USA within the time frame of 1971-1979 reveals that the interest of network effect is significant in utilizing an Automated Teller Machines (ATMs). Milne (2006) also encourages and supported the notion of the above authors. Interestingly, Kozak (2005) investigates the influence of the ICT evolution on the profit and cost effectiveness of the banking industry within the stipulate period of 1992-2003. For this period, the study declares a significant relationship between the executed ICT, productivity and cost savings.

The modernization of ICT has set the stage for extraordinary improvement in banking procedures throughout the world. For instance the development of worldwide networks has considerably decreased the cost of global funds transfer. Berger (2003), reveals' banks that are using ICT related products such as online banking, electronic payments,

security investments, information exchanges, financial organizations can deliver high quality customer services delivery to customers with less effort.

Brynjolfsson and Hitt (2000) point out that "ICT contribute significantly to firm level output." They determine that Information Technology capital contributes an 81% marginal increase in output, whereas non Information Technology capital contributes 6%. Likewise they illustrate that Information System professionals are more than twice as productive as non-Information System professionals. Farrell and Saloner (1985) and Economides and Salop (1992), showed that the relationship concerning Information and Communication Technology and banks' performance have two encouraging outcomes.

1. ICT can bring down the operational costs of the banks (the cost advantage). For instance, internet technology facilitates and speeds up banks procedures to accomplish standardized and low value added transactions such as bill payments and balance inquiries processes via online network.
2. ICT can promote transactions between customers within the same network (the network effect).

ICT has completely reshaping the landscape and the dimension of competition in the banking industry. Following the introduction of online banking, ATMs and Mobile banking, which are the initial milestones of electronic banking, the diffusion of ICT and increased penetration of Internet has added a new challenges and distribution channel to retail banking: online banking for the delivery of services and products.

4. Information and Communication Technology and Banks' Performance

However, research on the impact of ICT on banks' performance is insufficient and the available studies are more of US, European and Australian banking industry. Carlson *et al* (2000) and Furst *et al* (2002) conducted and intensive research whether there is a positive relationship that exists between offering electronic banking and bank's profitability. Furst *et al* (2002), reveals that federally chartered US banks had higher Return on Equity (ROE) by using the conventional business model, ICT was one of the major factors that affect bank's profitability within the period under study and they also observe that more profitable banks adopt ICT after 1998 but yet they are not the first movers. On the same note, Egland *et al* (1998), conducted a study and found no evidence of major differences in performance of electronic banking in the US subject to two caveats:

1. This result may not be the case for all the banks.
2. Such results are open to change over time as banks become more severe in the use of innovation.

While in a similar study in Kansas USA, Sullivan (2000) also found no systematic evidence that multi-channel banks in the 10th Federal Reserve District were either helped or harmed by having transactional web sites. These finding were among the previous findings of Sathye (2005), for the credit unions in Australian banks for the period of 1997 to 2001, shows that electronic banking has not proved to be a yard stick for performance enhancing tool. According to Haq (2005) banks' existence depend on their ability to achieve economies of scale in minimizing asymmetry of information between savers and borrowers. Today, one of the major challenges facing the banking industry is how ICT has helped banks to sustain the economies of scale whilst shifting from bricks and mortar banking to online banking.

Claessens *et al* (2001) buttress that, "Role of ICT in the banking industry can allow global economies to setup a financial system before first establishing a fully functioning financial infrastructure instead. Virtually, since electronic banking is much cheaper, it involves reduced processing costs for providers and less search and switching costs for consumers, banks can promote their services and products involving smaller transactions to lower income borrowers, even in remote areas.

Similarly, a research conducted by DeYoung (2005) analyzes the performance of the conventional banking versus the modern banking in the US market and find strong evidence of general

experience effects available to all start-ups. However, in a recent study, DeYoung *et al* (2007) invoke and find that, for US community banks and traditional community banks, those multi-channel banks are somewhat more profitable, mainly via increased noninterest income from deposit service charges. Movements of deposits from checking accounts to money market deposit accounts, increased use of brokered deposits, and higher average wage rates for bank employees were also observed for click and mortar banks. Whereas no change was explored in loan portfolio mix, these findings confirm Hernando and Nieto (2007) that internet banking is seen as a complementary channel.

Centeno (2004) in his study of analyzing the acceding and candidate countries' (ACCs) adoption of e-banking, classified e-banking adoption factors in two categories:

1. ICT factors: These factors involve internet penetration rates, skill of consumers in using internet and related technologies, attitude towards technology, security and privacy concerns.
2. Banking factors: This category includes trust in banking sector, banking culture, Electronic banking culture and Internet banking push.

In a similar research, conducted by Centeno (2004), he also stated that lack of PC and internet penetration is still an entry barrier for internet banking development both in EU15 and ACCs. The cost of access services is a main issue for the PC and Internet penetration especially in Central and Eastern Europe countries. On the other hand, there has been a lack of confidence in the banking sector in ACCs due to past turbulent periods. These concerns are further aggravated with privacy concerns. Magnitude of banking service usage and electronic banking culture are also weaker in ACCs compared to EU 15. A similar research with Centeno (2004), conducted by Gurau (2002), reveals that successful implementation and development of online banking is upon many interrelated factors. Today these aspects as in the current age in UK these factors have been dealt and overcome by the people. Now a day's skills of using internet and cost of accessing the technology, being at home, do not seem to be a stumbling block towards the adoption of innovation from the consumer perspective.

Simpson, (2002) reveals that electronic banking is motivated largely by the prospects of operating costs minimization and operating revenues maximization. An evaluation of online banking in developed and emerging markets reveals that in developed substitute for physical branches for delivering banking services.

5. Customer Service Deliver In The Banking Industry

Bloemer *et al* (1998) were on the view that most models in the banking industry of customer evaluations of services focus on the comparative judgment of expectations versus perceived performance resulting in the two major evaluative judgments of perceived service quality and customer satisfaction. For example:

1. Customers access service delivery by comparing their expectations prior to their service encounter with a bank (employee).
2. Customers also, develop perceptions during the service delivery process and then compare their perceptions with the actual service received from the bank's employee.

Thus, customer expectations are unique prior to a service. They influence customer's evaluation of service performance and customer satisfaction. Customer services, by definition, are intangible and easily duplicated. They can be divided into high-touch or high-tech services.

1. High-touch services are mostly dependent on people in the service process producing the service.
2. Whereas high-tech services are predominantly based on the use of automated systems, information technology and other types of physical resources.

However, one should always remember that high-touch also includes physical resources and technology based systems that have to be managed and integrated into the service process in a customer oriented fashion (Gronroos, 2001). Consequently, electronic banking services include both high-tech and high-touch services. For example, high-tech services include online banking, Mobile Banking, ATM machines, etc whereas high-touch services consist of instructions and personnel assistance in using the services.

Customer service delivery is differentiable and stem from the expectations of customers. Hence, it is necessary to identify and prioritize expectations for customer service and incorporate these expectations into a process for improving customer service delivery (Kassim and Bojei, 2001). Implementing and evaluating customer service is a very complex process. Zeithaml and Bitner (1996) reported that two aspects need to be taken into consideration when evaluating customer service:

1. Content
2. Delivery

Customers may be in the best position to evaluate the quality of service delivery, while the service providers are the best judges of the content of the message. Though there is a number of different aspect of services involved.

According to Parasuraman *et al* (1985), the study of customer service delivery has gained interest just after the concern on improving the quality of products appeared, and services are increasingly important in the global economy (regarding the participation in the GNP and job creation figures, for instance). Like machines transformed the agricultural economy into an industrial one, the information technology nowadays changes the industrial economy in such a way that it becomes characterized as based on services (Fitzsimmons, 2000).

The banking sector has already been depicted (e.g., in Parasuraman *et al*, 1993, and Mukherjee *et al*, 2003) as exhibiting little market orientation and fulfilling services with little regard to customer needs, as well as including branches dissimilar in efficiency (Berger and Mester, 1997). According to Mattos, (1999) the most frequent problems in using banking services are:

- Long lines.
- Limited time for customer servicing.
- Transaction errors due to the banks personnel.
- Excessive bureaucracy.

However, contemporary factors like more demanding and informed customers, the emergence of new technologies, and the competition increase (Cooke, 1997) modified the relationship between banks and customers, and strategies for survival and business expansion started to approach this seriously (Global Finance, 2000). In fact, customers determine the frequency of their contacts with banks based on the experiences they have with the services, and this exerts substantial impact on the profitability of banks in the long run (Bhat, 2005). Although, customers who are satisfied with service delivery are less likely to shift to other banks, therefore increasing such things as loyalty and retention (Al-Hawari *et al*, 2005).

Moreover, in as much as the customers want to be sure that they choose a bank perceived as being the best manager for their money, equally they also want a polite servicing and a trustworthy process. Barnes (1997) already said that no any service industry seems to be more interested in setting up relations with customers than the banking industry; however, the increasing deployment of ICT in financial transactions reduced the contact between bank and customers, modifying quite remarkably the general aspect of the relationship in fact, with the ICT having lowered information costs, customers were able to compare portfolios of investments between banks, or even invest directly (Cooke, 1997).

Interestingly, ICT in particular play an important role in the financial industry and this is one reason why the banking sector is among the most intensive in deploying ICT (Shoebridge, 2005). With the increase of Internet services and cash machines available in various locations, the most recurring problems have been mitigated and, in some cases, solved; as an effect, the volume of customer services increased became easier, and the customer experience turned out to be more comfortable. It is noticeable that the new technologies, particularly in ICT, enabled banks to service customers not only in branches and other dedicated servicing sites, but also in domiciles, work places and stop and shop stores, as well as in a myriad of other channels (Al-Hawari *et al*, 2005).

Thus, various issues related to the branches are another concern when dealing with the customer service delivery in the banking industry. For instance, access to the facilities (e.g., parking lot attributes and the mobility of people inside the branches), safety and convenience of location make customers access service delivery on a tangible basis (Castro, 1997); the branches external and internal architecture may mediate the perception of service delivery; while ATMs inside the branches simplify the customers procedures and lowers personnel costs, the number of human attendants is also important and vary according to demand, especially for reducing waiting times for certain services, providing human

interaction and servicing elder and less informed customers, who still seem to prefer people instead of machines as interfaces for their transactions (Dick, 2003).

Advertising practices and the banks institutionalized reputation within the community may be related to customer service delivery as well (Dick, 2003). Compton (1990) points out that another strategy for developing a good image within the market is to diversify the portfolio of services. As much as who uses many banking services is not likely to move to another bank, sponsoring social activities should also be considered.

6. Significance of ICT in the Banking Industry

ICT revolution has distorted the conventional banking business model by making it possible for banks to break their comfort zones and value creation chain so as to allow customer service delivery to be separated into different businesses. Thus, for example, primarily Internet banks distribute insurance and securities as well as banking products, but not all the products they distribute are produced by their group (Delgado and Nieto, 2004).

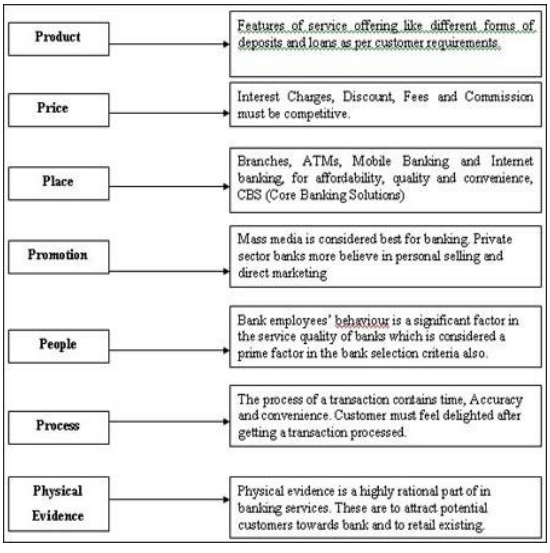
However, the main economic argument for diffusion of adopting the Internet as a delivery channel is based on the expected reduction in overhead expenses made possible by reducing and ultimately eliminating physical branches and their associated costs. This specifically applies to and relevant in the Spanish banking system, which is one of the most "over branched" in Europe. As stated by DeYoung (2005) and Delgado *et al* (2006), the Internet delivery channel may generate scale economies in excess of those available to traditional distribution channels.

Besides them, Haq (2005) also states that bank exists because of their ability to achieve economies of scale in minimizing asymmetry of information between savers and borrowers. The unit costs of Internet banking fall more rapidly than those of traditional banks as output increases as a result of balance sheet growth. In this context, DeYoung *et al* (2007) refer to the Internet banking as a "process of innovation that functions mainly as a substitute for physical branches for delivering banking services". In the case of the Spanish banks, there is some undependable evidence that shows that the Internet distribution channel has lower unit transaction costs than the two other distribution channels (branch and telephone) for a given type of transaction (money transfer, mortgage loan, brokerage or demand deposits).

7. Consumers' Behaviour in The Banking industry

Consumer behaviour is dynamic and to be studied regularly. Increasing awareness, globalisation, deregulation, living standards and urbanization has led to increase in the changing preferences and the same has forced the Banking industry to change their product features and customer service delivery. The study of consumer behaviour is compulsory to the banking industry, so as to know about likes and dislikes of consumers from time to time so that the products and customer services can be offered accordingly. Customers have their own unique needs, demands and preferences in a particular segment. Also, banks have to study customers in particular segment. Interestingly, the study of consumer behaviour can make it possible that after observing and examining the behaviour of consumer a Bank can present its product in such a way that the product can capture the market. Consumer behaviour indeed gives every possible answer to the complex questions concerned with consumer's buying reasons.

The following diagram will be elaborated considering all marketing decisions taken in the banking industry. All of them are essential decisions and are concerned with essential ingredients of services marketing mix.



Source: Mittal (2008), p. 225.

When customers are treated as the king of the Bank, the study of consumer behaviour becomes more important for marketing decisions. There is no doubt that the behaviour is the base of management decisions.

Birch and Young (1997) show that consumers seek convenience, transactional efficiency, a choice of core banking products and non-core products, and access to competitive returns and prices. The concept of internet has raised customer's sensitivity to fast and efficient customer service delivery. Cox and Dale (2001) categorise four factors in delivering customer service delivery through web site that are:

1. Ease of use
2. Customer's confidence
3. Online resources
4. Relationship services.

Each class relates to a different part of the website experience and serves to improve and exceed customer satisfaction. Ease of use is associated with all factors relating to the design of website. The key site seeks to, during the course of customer navigation, reduce customers' frustration. The fundamental nature of website means that communication with the customer has to be enabled through the use of text, graphics and animation.

All these factors relate to design of the web site and if the design is poor and not user friendly it cannot then achieve customers' expectation. The spread of electronic banking should also benefit consumers by reducing the time and inconvenience of banking transactions and, in very small communities, by providing access to banking services that might otherwise be unavailable. (Keeton, 2001).

Apparently, ICT creates unprecedented opportunities for the bank sector in the ways they organize financial product development, delivery, and marketing via the Internet. While it offers new opportunities to bank sector, it also brings many challenges such as the innovation of ICT applications, the blurring of market boundaries, the breaching of industrial barriers, the entrance of new competitors, and the appearance of new business models Cheung, *et al* (2003) and Saatcioglu *et al* (2001). Basically, ICT is associated with a lot of benefits, risks and new challenges for human governance of the developments (Hamelink, 2000). Today, the challenges are rapidly increasing with the pervasiveness of the Internet and the extension of information economy (Holland and Westwood, 2001).

However, to successfully cope with the challenge of the ICT, the bank sector must understand the nature of the changes that revolves around them, changes in terms of ICT, Innovation and Demography. Without this understanding, attempts to migrate to ICT may be doomed to failure. Today, banks that are well equipped with a good grasp of the electronic banking phenomenon will be more able to make informed decisions on how to transform ICT and to exploit the opportunity in electronic banking. (Southard *et al*, 2004). In today's competitive market, establishing core capabilities can help the banking industry reorganize their product and customer service delivery, so as to sustain competitive advantages and to achieve congruence whilst shifting from the conventional banking to electronic banking.

However, consumer behaviour affect person's usage of electronic banking, obviously a person should have an access to a computer with an Internet connection either at home or in the office. It is possible to use computers with Internet connection also in some of the self-service branches. Apparently, the research of online shopping reveals that prior web experience has positive impact on the persons' beliefs about ICT in general (Crisp *et al*, 1997, p 4) and it is quite obvious to draw a conclusion that the same applies also for electronic banking. Consumers who are on ease with ICT and use them also for other purposes find it convenient to start using electronic banking.

In addition, personal characteristics have been identified as significant predictors of consumers' adoption of an innovation various researchers have shown that it is the perceived attributes of the innovation itself rather than the characteristics of the innovators that are stronger predictors of the adoption decision (Black *et al*, 2001, p 391, Polatoglu, Ekin 2001, p.157)

Clients demand a minimum relative advantage in order to switch channels. It means that the new innovative service should be perceived to be better than its predecessor. In the case of electronic banking this is achieved via two strategies: added convenience and price incentives. The branch banking venue is characterized by long waiting lines and slow service and it is quite logical that those who have the possibilities try to use electronic banking. Also, the negative motivation of pricing has been successfully

used by the banks. Electronic banking transactions are either considerably lower priced or without any fee at all but for the transactions in branches the fees are very high according to the Banks standard. That is definitely one of the main reasons why the branch transactions are quickly losing their popularity.

8. Conclusions

The banking industry which is the back bone of every economy is confronted with various challenges such as globalisation, deregulation, competition, significant high cost of installing ICT and maintenance. The usage of ICT can lead to lower costs, but the effect on profitability remains inconclusive, owing to the possibility of ICT effects that arise as a result of consistence high demand of skilled work force, issues of increasing demand to meet customer's expectation for customer service delivery, trustworthiness of the information system and competition in financial services.

However, from the discussion whilst reviewing literature many researchers did not find ICT, for the delivery of customer service and profitable for bank's financial performance. So there has been an arrow head among these findings on perspective of profitability and customer service delivery. While, on the same vein, other researchers found ICT channel making profitable impact on the banks that are only internet start-ups than the conventional banks transforming into click and mortar.

In addition, there are other studies that proclaim due to perceived security risk, lack of comfort with computer technology, either due to lack of awareness or age factor, and a host of other reasons that ICT did not appear to be significantly viable or accepted warmly or quickly by consumers. Other researchers also found that despite all these factors banks, themselves, have been unable to have provided efficient customer service delivery because of which the clients who were even ready to adopt this delivery channel did not turn up again to innovation, and banks couldn't successfully build the required contents of electronic banking environment for consumers. More research need to be carrying out in different location and different time frame may confirmed or refute the previous findings by collecting the primary data to come up to a conclusion for the impact of ICT on customer service delivery and banks performance.

It is quite evident from our study that enhancing ICT in the banking industry is a must in a rapidly changing market place, as the ICT revolution has set the stage for exceptional increase in financial activity across the globe.

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