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Risk in Public Enterprises

Cases from the Greek Public Sector

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■ JORDANIS ELEFThERiADIS¹

Public enterprises are responsible for a wide and diverse range of activities including, delivering services to the public such as social welfare benefits and health care; procuring and managing major equipment and construction projects; sponsoring research and development; regulating industry and collecting revenue. All of these activities involve some form of risk – the risk that planned levels of service delivery are not met, or may be delayed or that access is denied to some citizens intended to benefit from a government program; the risk of financial loss, fraud, waste or inefficiency; or the risk that opportunities to deliver services in new ways are missed. One of the central objectives of the European Union is the liberalization of markets and, in particular, of utility sectors such as energy, telecommunications, transportation and postal services. The transition process from monopolistic to liberalized market generated a new business environment for public enterprises. In achieving and maintaining a competitive edge in a rapidly changing world, public enterprises have to face many challenges. The scope of this paper is to identify the possible sources of risks and the types of risks faced by public enterprises. We present two case studies from Greek Economy. The first one concerns Hellenic Telecommunications Organization (OTE S.A.) and the second concerns Olympic Airways, the flag carrier airline of Greece.

Keywords: Risk, Public Enterprises

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1. Introduction

Every organization faces different risks, based on its business, the economic, social and political factors, and the features of the industry it operates in. Each organization needs to identify the possible sources of risks and the types of risks faced by it. This requires an intimate knowledge of the organization, the market in which it

operates, the legal, social, political and cultural environment in which it exists, as well as the development of a sound understanding of its strategic and operational objectives, including factors critical to its success and the threats and opportunities related to the achievement of these objectives. In this paper we try to identify the types of risk faced by public enterprises. We use two

different case studies as examples. The first concerns the Hellenic Telecommunications Organization (OTE S.A.) and the second concerns Olympic Airways, the flag carrier airline of Greece. We describe the risk types that compose the total risk for these public enterprises and we discuss the similarities and the differences.

2. Types of Risk

Risk can be defined as the combination of the probability of an event and its consequences. In all types of undertaking, there is the potential for events and consequences that constitute opportunities for benefit or threats to success. We often focus on the negative aspect of risk but it is important to remember that risk includes both positive and negative events. Risk should be viewed as a product: qualitatively, the chances of an event happening, multiplied by the severity of that event if it does happen. People and organizations typically swing between the two extremes: focusing on highly probable events even though the consequences of them occurring would be relatively trivial, through to cataclysmic but highly improbable events that require endless scenario planning and back-up systems to prepare for (Wilson A., 2005). The risk identification process must be comprehensive, as risks that have not been identified cannot be assessed, and their emergence at a later time may threaten the success of the organization and cause unpleasant surprises. Risk identification should be approached in a methodical way to ensure that all significant activities within the organization have been identified and all the risks flowing from these activities defined. Examples of risks arising from internal activity are the risk of failure to meet policy objectives and project targets through not identifying obstacles to implementation, project overrun, poor management of finance and resources, or fraud. Other risks arise from the external environment, not wholly within the organizations control, but where action can be taken to mitigate risk, for example, legal, technological and political risks. Other examples of external sources of risk include the demographic trends, or acts of nature. Information used in the risk identification process may include historical data, theoretical analysis, empirical data and analysis, informed opinions, and the concerns of stakeholders. The output is a comprehensive list of possible risks, usually in the form of a risk register, with management responsibilities allocated to

them. A list of the most important types of risks faced by public enterprises is the following (Eleftheriadis and Agorastos, 2006):

- Pure risk addresses the possibility of injury or loss. It focuses exclusively on the occurrence of bad things. According to Mowbray, the possible outcomes from activities or events exhibiting pure risk range from zero to negative. Some examples of pure risk are the following: an organization is exposed to the possibility of fire loss to its plant and equipment; assets may be stolen (Doherty, 1985). The reason it is often referred to as insurable risk is that when you take out an insurance policy, you are protecting yourself from the consequences of damage or loss (Williams, and Heins, 1989).
- Business risk is the risk of failing to achieve business targets due to inappropriate strategies, inadequate resources or changes in the economic or competitive environment. Inquiries into government decision making often produce examples of risks being taken with public money or the quality of public services without adequate strategic consideration at senior management level or careful contingency planning. Yet public servants are almost equally often berated for being too risk-averse and not sufficiently entrepreneurial. Typical risks that public enterprises may face are the following: Economic changes such as lower economic growth reduce tax revenue and opportunities to provide a wider range of services or limit the availability or quality of existing services. Higher than expected public demand for service causes breakdown in delivery. Failure to innovate leads to sub-standard services compared with other public and private sector providers.
- Credit risk, is the risk that a counterpart may not pay amounts owed when they fall due. Sovereign risk the credit risk of public enterprises is usually associated with liabilities of the government itself or a party guaranteed by the government. This type of credit risk is called sovereign risk.
- Market risk, is the risk of loss due to changes in market prices. This includes interest rate risk, foreign exchange risk, commodity price risk and share price risk. Unfortunately many organizations, fail to appreciate market risks and take on quite significant risks sometimes in ignorance. Doing nothing is a risk

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decision. Failing to hedge risks means that they are actually accepting the open-ended risk that rates will move against you. They will clearly benefit if rates move in their favor but they will feel the downside loss more than the upside gain. A factor stopping some finance directors doing this is cost and personal credibility. If they take out a hedge and the current price on the date of the contract is better than the contracted rate, they may be accused of costing the organization money. If rates move against the company it is easy to blame the market.

- Operational risk the risk of loss due to actions on or by people, processes, infrastructure or technology or similar, which have an operational impact including fraudulent activities. Operational risk addresses the risks associated with carrying out operations. Included here are such matters as running an assembly line, managing an office, and operating a computer facility. Risk arises when events occur that threaten operations in some way. The risk of fraud and corruption is intrinsically high. The areas of public sector activity where there is scope for individual judgment in the application of public funds, or the exercise of public power, to private sources are currently of most concern. The general interaction of public money and private enterprise and specifically, the awarding of public contracts, allocation of subsidies, licensing and levying fees offer 'opportunities' for fraud. Additionally, we could add to the list privatization, cross-border transactions and collection of tax and customs revenues. Possible obstacles to the successful control of corruption are the complex regulatory and administrative controls, and the multiplication of funding provisions. The influence of organized crime on public officials was a secondary concern. Innovating to improve public services entails risk. We are rightly critical where risks are ignored, for example where major IT projects are poorly specified and managed. Failure to implement IT change, for instance, could result in inadequate systems at operational level leading to poor delivery of services to the public, jeopardizing the ability of partners in a organization's delivery network to deliver and providing opportunities for fraud, resulting ultimately in damage to a organization's standing with external stakeholders. The Internet and technology in its broadest sense have led to significant changes in how

businesses operate as well as the development of entire new industries which has led to many more new operational risks – hacking, computer failure, mis-routing of e-mail, etc. Staff issues are also a source of operational risk. Finding good staff may be problematic but getting rid of them if they do not perform as expected can be very difficult. They have good benefits; they will not want to leave while labor laws may prevent their being made redundant.

- Political risk refers to situations that exist when decision-making is heavily colored by political factors. We mean risks relating to the achievement of public policy objectives. The differentiation of policy objectives may result to an increase or decrease of political risk.
- Environmental risk, the risk that an organization may suffer loss as a result of environmental damage caused by themselves or others which impacts on their business. Environmental risk has come to the fore in recent years. Many environmental elements exist in or are being discussed in relation to the tax system, such as for example a CO2 energy tax or increased value added tax on energy. Minimum environmental levies will be adopted through effective coordination among the EU Member States to expedite the 'polluter pays' principle. The main purpose is to clarify how national environmental taxes and charges can be brought into line with Community law with regard to the single market. At a later stage the Commission will examine the question of the broad economic impact of environmental taxes and charges, including their effect on the creation and destruction of jobs and on international competitiveness.
- Legal/regulatory risk is the risk of non-compliance with legal or regulatory requirements. A problem for most organizations is the volume and complexity of the law and regulations that have increased substantially in recent years. In addition, as operations have spread nationally and globally, complexity has increased, as there may be multiple requirements, which must be met. In the US, for instance, there is a complex web of national and state level legislation. In Europe there are national, local and European Union laws to comply with. It is not surprising that failures to comply may come about simply through ignorance though that is never an acceptable defense.

The concern for organizations, therefore, is the possible consequences of failure to comply. At one extreme they can be fairly mild – censure or rebuke – ranging to large fines or even closure at the other. For management there can be adverse consequences as some laws make them personally responsible, and fines or even jail sentences are not unheard of. With the trend for more rather than less legislation and regulation and companies spreading globally at a faster pace, the probabilities of problems occurring is increasing significantly. It tends to be one of the most important risks faced by public enterprises. The principal risk associated with regulations is sudden changes in the rules. You may find that basic procedures you carry out in your organization become illegal over-night with the stroke of a regulator's pen. Or you may discover that to garner the resources needed to comply with a change in regulations, you must divert them from uses that are crucial to your growth strategy. The transition process from monopolistic to liberalized market generated a new business environment for public enterprises. The legislation decreases the privileges and restricts the government financial aid.

- Systemic risk is the risk that a small event will produce unexpected consequences in local, regional or global systems not obviously connected with the source of the disturbance. By systemic risk we mean risks affecting a set of organizations (like risks of general banking collapse), as distinct from risks to the position of any individual organizations. The best example of systemic risk or at least the threat of systemic risk, in recent years was the so-called Millennium Bug (Olsson, 2002). There was great concern across the globe that come the start of the year 2000 all sorts of systems which relied on technology involving date recognition would fail. Much was written about how systems would crash, utilities would fail and there would be panic or riots in the streets. Much work was done to address this potential problem, but one of the issues encountered was the huge range of possible outcomes, potential risk scenarios were more or less endless and it was difficult to visualize how things were connected. The way this problem was approached was to seek to identify, in a systematic way, potential life threatening events, assessing their probability of occurring and their

potential impact. From this analysis it was generally possible to find some order in chaos and focus limited resources on the key areas. The problem was that it was difficult to be objective and a large degree of judgment was required because of the uniqueness of the situation – no one had any prior experience of such an event.

- Reputational risk is the risk that the reputation of an organization will be adversely affected. Reputational risk is largely a secondary risk. Reputational risk occurs principally as a result of failure to manage the other types of risk effectively. The most important thing to remember about reputation is that it can take a long time to build up, but a short time to destroy, so reputational risk is something that must be taken seriously at all levels in an organization.

3. Case studies

3.1 Hellenic Telecommunications Organization

Hellenic Telecommunications Organization (OTE S.A.) is the incumbent telecommunications provider in Greece and together with its subsidiaries forms the leading group of companies nationwide. OTE provides fixed-line telephony services to Greek and foreign businesses, consumers and government agencies. The Group also offers mobile telephony, Internet access, broadband, ISDN, high-speed data communications and leased lines services. OTE operates as a société anonyme under Greek law 2190/1920 as in effect, the Greek companies law, and we are registered with the Greek Register of Sociétés Anonymes under registration number 347/06/B/86/10. At the same time, OTE is among the five largest listed companies with respect to capitalization, in the Athens Stock Exchange. OTE is also listed in the stock exchanges of New York (NYSE) and London (LSE). Since 1996 (when OTE was a state-owned monopoly), the Greek state has been gradually reducing its participation in OTE's share capital. Today, the state owns 28% of OTE's share capital. With local, long distance and international communications services in addition to mobile telephony, Internet services, and high-speed data communications, OTE provides consumers and business the ability to communicate globally through its extensive network infrastructure. OTE's products & services portfolio includes:

- Local, long distance and international calling services
- High-speed data communications responsive to the increased market demand and flow of data traffic
- ADSL
- Integrated broadband data transfer services
- Intelligent network services
- Mobile telephony

In addition to the products and services provided in fixed line, mobile telephony and the Internet sectors, OTE is also involved in a host of additional innovative areas through its subsidiaries.

- B2B Electronic transactions
- Integrated telecom solutions and customer support to large corporations and telecom service providers located in Greece and international markets
- Wireless and satellite communications, including maritime services
- Consultancy services
- High-Quality education for professional excellence.
- Private insurance services
- Investment activities made by the same and/or by other companies of the OTE Group

Having established its leadership in the Greek telecommunications industry in 1997, OTE was ready to extend its resources, technology and expertise beyond the Greek borders. Today, OTE has a strong international presence in Bulgaria, Serbia, Romania, the Former Yugoslav Republic of Macedonia and Albania, where it is assisting its subsidiaries - all of which are very important contributors to the group - further enhance their telecommunications infrastructure and harness the benefits of advanced network building. OTE, through its investments in South-East Europe, addresses a potential customer base of 60 million people. As part of its international investment strategy, OTE Group has acquired stakes in telecom companies mainly in the area of South-East Europe. More specifically, OTE has acquired stakes in Telecom Serbia (20%), and in Romtelecom, Romania (54%). OTE is also present in the mobile telephony market of Bulgaria through GloBul and in the Former Yugoslav Republic of Macedonia through Cosmofon. OTE subsidiary, COSMOTE, acquired recently both Globul and Cos-

mofon, while it also owns 82% and manages the mobile telephony company AMC (Albania). Moreover, at the end of June 2005, COSMOTE's Extraordinary Shareholders Meeting approved COSMOTE's participation in the share capital of the Romanian mobile operator, CosmoRom, with a 70% stake, while RomTelecom retains a 30% stake. On October 2005 OTE announced a strong voluntary retirement take up. Out of a final pool of 6,000 eligible OTE fixed-line employees, more than 5,500 elected to apply for early retirement. On August 2006 OTE receives the approval from EETT for the acquisition of GERMANOS S.A. On October 2006 OTE announced the successful completion of its Voluntary Retirement Program. On February 2007 OTE announced employee exit program with financial incentives. On June 2007 the Greek government announced the successful completion of the sale of 10.7% interest in OTE's share capital via an accelerated book build. On August 2007 OTE announced that the participation of Marfin Investment Group in OTE SA's share capital reached 5.30%, which finally reached the 19.9%. A new employee exit program with incentives for 2008 was announced on February 2008. On May 2008 OTE announces that Deutsche Telekom is planning to acquire the shares from Marfin Investment Group. This is the final step to privatization. All the facts that we presented above can help as identify the main risk types faced by OTE. These are the following:

Business risk: One of the central objectives of the European Union is the liberalization of markets and, in particular, of utility sectors, including telecommunications. The transition process from monopolistic to liberalized market generated a new business environment for OTE. New competitors came into the market of telecommunications. Initially they were activated in the mobile telephony. After the complete liberation of telecommunications market they also offered fixed telephony services. The competitive advantage of OTE was that the organization owned a well developed cable and satellite network. OTE also have already started to develop a new fibre optic network. The result was the reduction of business risk exposure.

Operational risk: The risk of fraud and corruption is intrinsically high. The areas of public sector activity where there is scope for individual judgment in the application of public funds to private sources are

currently of most concern. There is an investigation running, concerning the supply of, millions of Euros worth, technical equipment. The interaction of public money with private enterprises, and specifically, the awarding of public contracts, allocation of subsidies, offers opportunities for fraud. Additionally, we could add cross-border transactions. The mobile telephony and the development of technology in general have led to many more new operational risks including wire-tapping. Staff issues are also a source of operational risk. Finding good staff may be problematic but getting rid of them if they do not perform as expected can be very difficult. They have good benefits; they will not want to leave while labor laws may prevent their being made redundant. OTE have tackled this type of operational risk by the implementation of a voluntary retirement program, offering strong financial incentives to the employees that agreed to retire. Nevertheless, there was an adverse consequence. Some of these employees were employed from the competing companies, carrying with them their know-how.

Legal/regulatory risk: The transition processes from monopolistic to liberalized market decreased the privileges for OTE. The organization faced regulatory problems concerning EETT, the National Regulatory Authority, which supervises and regulates the telecommunications as well as the postal services market. EETT have imposed heavy fines (more than 3 million euros) for failure to comply with the regulation of the European Committee.

Reputational risk: Reputational risk occurs principally as a result of failure to manage the other types of risk effectively. The most important thing to remember about reputation is that it can take a long time to build up, but a short time to destroy, so reputational risk is something that must be taken seriously at all levels in an organization. OTE have managed to treat effectively reputational risk. A survey carried out in 2006 by Tradelink Reputation Research & Consultancy ranked OTE among the 20 companies with the best reputation in Greece. A former survey carried out by Tradelink Reputation Management at 2005, concludes that OTE is the company with the best reputation in Greece, in terms of its working conditions and corporate social responsibility. Finally according to the MEDA Communication

Company the general public acknowledges OTE, as the top company for its work and activities towards society

3.2 Olympic Airlines

Olympic Airlines (OA) is the flag carrier airline of Greece, based in Athens. Its main base is Athens International Airport, with hubs at Thessaloniki International Airport, "Macedonia" and Rhodes International Airport, "Diagoras". By December 2007 the airline employees about 8,500 staff. OA-Services S.A. consists of 5 subsidiary Companies and 7 Corporate Directorates enjoying a leading position in the international airline market. The following are the most important:

Olympic Airways-Services S.A provides a full range of ground services through its Ground Handling Unit. The Unit is the oldest, in Greece, recognized as the leading regional handling agent, well known for the high quality of services as well as the safety and security standards that offers to its clients, in accordance to the international rules and I.A.T.A regulations.

Olympic Airways-Services S.A Cargo Unit operates in air transport of freight and mail. It provides cargo sales and handling services to Olympic Airlines as well as cargo and handling services to a variety of customers, such as Airlines, Public Services, Individuals, IATA & NON IATA agents.

Olympic Airways-Services S.A. Technical Operations Department: It's main function is the support of Olympic Airlines fleet in all aspects of Line, Base and Shop Maintenance. It also offers technical support to other airlines flying to Greek airports as well as extended third party work.

The Information Technology Corporate Unit (ITCU): ITCU offers services, develops, deploys and supports Information and Telecommunications applications and hardware to serve the full range of operations for both Olympic Airways-Services S.A. and Olympic Airlines in Greece and abroad.

Olympic Airways-Services' Training Center provides intergraded training solutions both to OA's Group as well as to other established Greek enterprises involved in the air transportation chain. OA's Training Center mission is to strengthen the appropriate technical & administrative skills and knowl-

edge of people involved in the Greek air transport market via well-structured training seminars, so as to enhance the overall performance of their companies.

Helicopter chartering in Greece began in 1967 upon the creation of the Light Aircraft Department of OLYMPIC AIRWAYS, using two 4-6 seats helicopters. Passengers transportation, air-photography, aerial survey of various events, cargo and spare parts transportation, air filming, supervision of industrial works by air, VIP and business trips, have been some of the standard activities of the company's helicopters. In cooperation with EKAV until the year 2000, the company carried out a multifarious work in emergency medical field.

The Professional Pilot School provides the educational background and training for Commercial Pilot License (C.P.L.) for aircrafts and helicopters.

Olympic Airways was officially born on April 6th, 1957 as a private company. The new company developed rapidly. In 1971, Olympic Aviation was created, so that the Greek islands could be more efficiently served. In 1973, OA was sold to the Greek state. In 1976, under the state management, OA created Olympic Catering, which served both OA and foreign airlines. In 1984, a new Olympic Airways Cargo division was created. The company has faced serious financial trouble since the 80s, mostly because of its dubious management. In fact, the management has not only been haphazard but the airline was used as an employment provider for politically connected individuals, and was severely indebted as a result. Olympic Airways is an example of the politically motivated management. Furthermore, Greek politicians and the families of OA employees travelled free on the airline or for token amounts. Greek governments also made Olympic carry the press with a 97% discount. Olympic Tourist was created as a subsidiary of OA, which issues tickets not only for OA, but for other airlines as well. In 1986, the worst strikes in the history of OA occurred whilst financial losses mounted. A few years later, in an attempt to make OA profitable, its management was given to the subsidiary of British Airways. At the same time (March 1999) Aegean airline is established. Aegean airline became the main competitor of OA. The result was even larger debts and rising losses. Very soon, the losses recorded exceeded all expectations, so in 2003 the government decided to

restructure the Olympic Airways Group of Companies. On October 2003 Aegean Airlines launched e-ticket, a new innovative service that offers the opportunity of booking and issuing a ticket at the same time. On 12 December 2003, Olympic Airways ceased to exist as an air carrier, after 40 years of operation, and a new company entitled Olympic Airlines took its place. This followed a decision earlier in the year by the Greek government to privatize and restructure the financially troubled Olympic Airways group, in which it is the main shareholder, in the light of the problems in aviation caused by the events of 11 September 2001 and the war in Iraq, and in an attempt to ensure the conditions for the company's survival in the context of EU competition rules. The subsidiary, Macedonian Airlines S.A., was renamed Olympic Airlines S.A. and took over the flight operations of Olympic Airways, erasing at the same time all of the airline's debts. The remaining group companies, except for Olympic Aviation (Olympic Airways, Olympic Into-Plane Company, Olympic Fuel Company, Olympic Airways Handling and the Olympic Airways Technical Base), merged and formed a new company, called Olympic Airways-Services S.A. In December 2004, the Hellenic Government decided to privatize Olympic Airlines. In 2005, the Greek Government looked for potential buyers to privatize OA. In April of that year, a short list of potential buyers was submitted that included Aegean Airlines, German LCC DBA and a Greek-American consortium called Olympic Investors. Shortly Aegean Airlines pulled out, followed by DBA. In September 2005, the Greek government signed a non-binding agreement with Olympic Investors to buy the airline. They stated that OA should continue to operate as an integrated company and that they weren't interested in buying just parts of OA. By the end of the year, the offer fell through because of the huge fine (almost 500 million Euros) imposed on the airline by the European Commission. At February 2006 the Greek government, decided to re-launch the company, giving its place to a new airline, possibly with fewer destinations, and much fewer staff. Under this plan the government would be a minority shareholder of the new carrier and it will be run as a private airline. Olympic Airlines have re-designed their website to introduce the e-ticket service launched on July 31 2007. The e-ticket service introduction by EDS meant Olympic abolished their old "Hermes" booking sys-

tem which had served the company for more than two decades. As of November 2007, the e-ticket service is available on all European and International routes, and on 19 of the airline's 37 domestic routes. Although OA launched e-ticket, almost 4 years after Aegean Airlines they only offered online booking but they don't offer online check-in. In November 2007, Irish airline Ryanair filed a suit with the European Commission, saying it had not looked into claims by the airline that Olympic has not paid back its debt. On December 01, 2007 the Greek government announced that the entire Olympic Airways Group debts amount to 2 billion euro, and that the airline in its present form and size will cease existing in 2008. The Greek government was under more pressure to recover the money Olympic owes, thanks to the Ryanair lawsuit. The government plans to close the airline in 2008, and open up a smaller airline, selling it immediately after. It will continue its domestic services as well as limited international services at the wish of the EC. This seems to be the only way for the European Commission to write off the company's debts to the Greek public sector. The minister of transport announced that none of the estimated 8,500 jobs would be lost, and service to the islands will be maintained since it is an important mode of transportation for many of the islands while for some it is the only mode. He also stressed that Olympic will not be replaced by another monopoly carrier on domestic routes. The result was a new round of strikes that caused delays and cancellations of flights. Nevertheless, actual figures show, that Olympic still retains 49% of the route traffic on destinations that both companies fly to. Traffic for Olympic in 2007 increased, carrying a total of 5.977.104 passengers (3.115.521 in domestic and 2.681.583 in international flights) as opposed to approximately 5.500.000 passengers in 2006. It is estimated that OA earned approximately 780 million euro in 2007, 500 of which came from international flights.

All the facts that we presented above can help us identify the main risk types faced by OA. These are the following:

Business risk: there are critical changes in the economic and competitive environment. The crisis caused by the events of 11 September 2001 and the war in Iraq provoked serious economic problems in aviation. The business environment and the economic growth rate were affected, limiting the availability or

quality of existing services. There was also an important change in the competitive environment of OA. A new competitor, Aegean Airlines was founded and progressively conquered a very important share of the market. At the same time, Aegean airlines by providing high level of services to the customers created higher expectations with regard to the quality of provided services to the public.

Operational risk: Operational risk addresses the risks associated with carrying out operations. There are not airplanes ready to cover a technical problem that might keep an airplane on the ground. The result is the delays or the cancellation of flights in a daily basis. Another problem that increases operational risk is the failure to implement IT change and innovation. For instance, OA launched e-ticket. But the service is incomplete because it offers online booking but it does not offer online check-in. Staff issues are also a source of operational risk. The selection of personnel was based mainly on political criteria and not according to the operational needs of the company. Finding good staff may be problematic but getting rid of them if they do not perform as expected can be very difficult. Strikes, organized frequently, express the opposition of employees to the privatization plan of the government. Strikes increase the level of operational risk. The uncertainty caused with regard to labor relations and employment once again highlight the major problems created by company restructuring and privatizations. At stake are the viability and competitiveness of Greece's national air carrier and the maintenance of workers' jobs and rights.

Legal/regulatory risk: Legal risk proved to be critical for OA. The European Community in order to achieve the liberalization of transportations market forbids the government financial aid. The European Commission found the Greek government guilty of illegal state aid to OA. Greek government has given Olympic Airways and Olympic Airlines an advantage not available to their competitors. The Commission therefore asked Greece to recover the illegal aid payments. The Commission is still waiting for OA to return the 540 million euros of state aid it has received since 2002. The EU's Court of Justice ruled that Greece had failed to take necessary measures to recover the subsidies from the carrier, prompting the

Commission to request in 2006 that the EU court impose fines against Greece. Ryanair has taken the European Commission to court for failing to act on further state subsidies it alleges were paid to Olympic. The legal action by Ryanair makes Olympic's survival more difficult.

Reputational risk: Reputational risk is largely a secondary risk. Reputational risk occurs principally as a result of failure to manage the other types of risk effectively. The frequent delays and cancellations of flights have harmed considerably the reputation of OA and undermined the confidence of the customers. Thus, OA does not constitute the first choice for the realisation of their travels. On the other hand the OA has very good reputation with regard to the safety of flights. The most important thing to remember about reputation is that it can take a long time to build up, but a short time to destroy, and very difficult to recover. So, reputational risk is something that must be taken seriously at all levels in an organization.

4. Conclusions

The scope of this paper is to identify the possible sources of risks and the types of risks faced by public enterprises. We presented two case studies from Greek Economy. The first one concerns Hellenic Telecommunications Organization and the second concerns Olympic Airways, the flag carrier airline of Greece. The main conclusions drawn from the former analysis are the following:

- Over the last two decades, declining prosperity, financial pressures and limited resources caused a change, especially in public sector management.
- Threats and opportunities are identified through ongoing internal and external environmental scans, analysis and adjustment.
- The environmental scan increases the organization's awareness of the key characteristics and attributes of the risks it faces. These include the type and the source of risk of risk, the area of impact/type of exposure and the level of ability to control the risk.
- An organization's success today is less and less determined by, its physical assets, hierarchical structures and uniform rules. It is increasingly determined by

its ability to network, to innovate and to take reasonable risks.

- Delivery of modern and efficient public services increasingly requires reliance upon delivery networks of organizations including local authorities and private sector organizations. Inevitably, this creates new and increased risks and organizations need to apply the same principles of accountability, challenge and openness that they apply to their internal risk management so that responsibility for managing risk is clear throughout the delivery network.
- Public enterprises need information on costs, the preferences and needs of key beneficiaries of public services and data on a wide range of aspects of performance such as waiting times, productivity and quality of service. Equally importantly they require data on likely future happenings and estimated economic performance.
- Citizens and businesses can waste time and lose out financially if public services are inadequate or inefficiently delivered. And the reputation of organizations can suffer where services fail to meet the public's expectations.
- Public enterprises need to signal their commitment to risk management by drawing a direct link between the structures and processes they have put in place and the better achievement of organizational objectives and targets.
- Risks and opportunities do not arrange themselves around organizational boundaries, and organizations need effective mechanisms to work together, to share knowledge, information and understanding about risks, and how to address them.

Finally, from the analysis of the case studies we have conducted the following conclusions:

- Public enterprises are responsible for a wide and diverse range of activities All of these activities involve some form of risk.
- Risk management might consider a regime of risk management guidance that recognizes the uniqueness, differences and similarities of public sector organizations. It is very difficult to design a general strategy for the identification and management of risk that could be implemented successfully to public sector organizations.

- The most important and critical risks faced by public enterprises are business risk, operational risk, legal/regulatory risk, political risk and reputational risk.
- As we analysed in the first case study, OTE is a leading company in the telecommunication sector of Greek economy. OTE implements an aggressive commercial strategy to contain competitive pressure. With a strong resolve to maintain its market leadership position in an increasingly competitive environment, OTE is continuously monitoring and reviewing the performance of other major European players trying to identify those factors which have a decisive influence on value creation. The main risks faced by OTE are business, operational and regulatory risk. None of them seems to be critical.
- The second case concerns OA. The answer to O.A. problems of protectionism, labor unions, governmental intervention and neglect has to be the privatization of the company, making it responsible to private business shareholders who will insist upon its profitability. The main risks that OA has to manage in order to succeed are business risk, reputational risk, operating risk and legal/regulatory risk.

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Are adjusted asset pricing models a good panacea for abnormal returns in emergent market?

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The recent studies in financial markets seem to produce many abnormal returns. Although subjected to scrutiny, the evidence does not advocate that market efficiency will be abandoned. Since the literature has not provide a specific substitute to market efficiency to acquire the ball rolling, authors try to find reasonable changes in the way abnormal returns are measured. Fama and French (1993) and Acharaya and Peaderson (2005) stipulate that adjusting fundamental models to microstructural data such size, book to market and liquidity causes this anomaly to disappear.

Including in this way, we try in our paper, firstly, to detect determinants of Tunisian stock market inefficiency. And secondly, we test if matching microstructural data to asset pricing models can remedy the existence of abnormal returns. Our conclusion is that this anomaly will likely fall prey to psychological bias.

Keywords: abnormal return, emergent market, risk liquidity, multi-criteria model
JEL Classification: G14, C13, C22, C51

1. Introduction

The theory of efficiency dominates the explanation of the dynamics of financial markets. It supplied stable and significant results in the explanation of stock returns. However, it undertakes several critics at various levels. Certain works criticizes the basic hypotheses of this theory. We can cite as example the critics relating

to the hypothesis of the rationality of the investors, advanced by behavioral researchers. Other criticisms concern the existence of abnormal returns on several financial markets, that the theory of the efficiency is incapable to explain their persistence.

According to Hansson (2001) the stock market is efficient in the sense that every single stocks' pricing is set

in accordance to all information available, therefore it does not add any value in making your own analysis. If there would exist an easy way to obtain abnormal return on capital, other investors would soon have knowledge of this method and the possibility of abnormal returns would disappear. The efficient market is further distinguished of that all investors are maximizing profits meaning that no single investor can affect the price of a stock.

For the validation of the existence of abnormal returns, most of the empirical studies use almost the same methodology, which consists in studying the behavior of the stock returns around a specific event. This methodology, called the event study, is the native of several analyses.

In front of the existence of abnormal returns, defendants of the efficient market theory try to explain them by specific and microstructural factors like: size effect, book to market effect and liquidity effect. The validation of certain anomalous on financial markets initiate some researchers to adjust fundamental models to the detected anomalies, as the case of Fama and French (1993), for the size and book to market effects, and the case of Acharya and Pederson (2005) for the liquidity effect. The question which arises at this level is: Do these models cancel the existence of abnormal returns?

The paper is organized as follows. The second section develops the literature review and describes the data. In the third we try, through a cross-sectional study, to loosen the determiners of the inefficiency of the BVMT. In the forth, we check if extensions of fundamental models adjusted to microstructural factors can cancel the existence of abnormal returns. The conclusion will be in the last section.

2. Literature Review and data base

2.1. Literature Review

For the validation of the existence of the abnormal returns, most of the empirical studies used almost the same methodology, which consists in studying the behavior of the stock returns around a specific event.

Brown and Warner (1985) test whether the event-day abnormal return is significantly different from portfolio returns over the estimation period. This test is commonly called the traditional test. Brown and Warner also suggest using a cross-sectional test using the

standard deviation of the portfolio's event-day abnormal returns, which tests whether the abnormal return on the event day equals zero.

Schwert and Seguin (1990) propose and estimate a single factor market model of portfolio returns, which incorporates the estimation of the time-varying component of beta. As market volatility increases, the systematic risk of small firms increases at a faster rate than those of large firms, given that small firms are less diversified and more vulnerable to shocks. Therefore, the spread between the systematic risk of small and large firms is larger during periods of high aggregate market volatility. The Schwert and Seguin results show that the small firm portfolio variances are four times more sensitive to market volatility changes than the large firm portfolio variances.

The Fama and French (1993) three factor asset pricing model was developed as a result of increasing empirical evidence that the Capital Asset Pricing Model performed poorly in explaining abnormal returns. In fact, Fama and French [hereafter FF] (1992a) studied the joint roles of market beta, size, Earnings/Price (E/P) ratio, leverage and book-to-market equity ratio in the cross-section of average stock returns for NYSE, Amex and NASDAQ stocks over the period 1963-1990. In that study, the authors find that beta has almost no explanatory power. On the other hand, when used alone, size, E/P, leverage and book-to-market equity have significant explanatory power in explaining the cross-section of average returns. When used jointly however, size and book-to-market equity are significant and they seem to absorb the effects of leverage and E/P in explaining the cross-section average stock returns. FF (1992a) therefore argued that if stocks are priced rationally, risks must be multidimensional.

Fama and French (1993) extend the FF (1992a) study by using a time-series regression approach. The analysis was extended to both stocks and bonds. Monthly returns on stocks and bonds were regressed on five factors: returns on a market portfolio, a portfolio for size and a portfolio for the book-to-market equity effect, a term premium and a default premium. For stocks, the first three factors were found to be significant and for bonds, the last two factors. As a result, Fama and French (1993) construct a three-factor asset pricing model for stocks that includes the conventional market (beta) factor and two additional risk factors re-

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lated to size and book to market equity. They find that this expanded model captures much of the cross section of average returns amongst US stocks.

Similarly, Chan and Chen (1991) posit that small and large firms have different risk and return characteristics. Small firms on the New York Stock Exchange are firms that have not been doing well, are less efficiently managed and are highly levered. As a result small firms tend to be riskier than large firms and that risk is not captured by the market index.

For instance, Lakonishok et al. (1994) find a strong positive relation between average return and BE/ME for the largest 20 per cent of NYSE-Amex stocks, where survivor bias is not an issue. Similarly, FF (1993) find that the relation between BE/ME and average return is strong for value-weight portfolios. As value-weight portfolios give most weight to larger stocks, any survivor bias in these portfolios is trivial. There are also many studies using different sample periods on US data and samples in different countries confirming the existence of the size and book-to-market equity effects.

Faff (2001) use Australian data over the period 1991 to 1999 to examine the power of the Fama French three-factor model. He finds strong support for the Fama and French three factor model, but find a significant negative rather than the expected positive, premium, to small size stocks. Faff (2001) concludes that his results appear to be consistent with other recent evidence of a reversal of the size effect.

Maroney and Protopapadakis (2002) tested the FF three-factor model on stock markets of Australia, Canada, Germany, France, Japan, the UK and the US. The size effect and the value premium survive for all the countries examined. They conclude that the size and BE/ME effects are international in character. Using a Stochastic Discount Factor (SDF) model, and a variety of macroeconomic and financial variables, do not diminish the explanatory power of BE/ME and MVE. Their evidence suggests that the BE/ME and MVE effects are not artefacts of the inadequacies of the augmented CAPM as an asset-pricing model or of omitting macroeconomic and financial variables. The positive relation of returns with BE/ME and their negative relation with MVE remain strong under a general SDF model.

Drew and Veeraraghavan (2003) compare the explanatory power of the single index model with the

multifactor asset pricing model of Fama and French (1993) for Hong Kong, Korea, Malaysia and the Philippines. They find that the size effect and book to equity effect are present in these markets and that the FF three-factor model explains the variation in returns better than the single index model. They suggest that the premium is a compensation for risk that is not captured by the CAPM.

Gaunt (2004) studies the Fama French three-factor model in the Australian setting and provides further out of sample (non US) tests of the model. The study covers the period 1991 to 2000 of firms listed on the Australian Stock Exchange. He finds that beta risk tends to be greater for smaller companies and those with lower BM ratios.

There is a lack of empirical evidence of whether the size and value premium are present in emerging equity markets generally, and particularly in the emerging African stock markets. This study provides some empirical evidence in Tunisia stock exchange as an emerging market

2.2. Database

The analysis includes monthly data for two indexes of the Tunisian stock exchange: BVMT and TUNINDEX, as well as for their constituent stocks. The sample covers 20 firms, where 10 are belonging to the banking sector. The data is obtained from the www.bvmt.com.tn Website of the Tunisian stock market from 2/01/1999 to 31/12/2005. So we have 1680 observations for each stock.

For some firms, there is loss of significance of the relationship between investor sentiment and return at the individual level. So, we separate individual stocks into four groups according to activity sector, size, book to market and liquidity criteria. We also aim to see if there are different relation between investor sentiment and returns on these classes.

According to these criteria, we subdivide our sample into two sub samples. Hence, we obtain sub samples of small and big size companies, great and small value book to market companies or liquid and illiquid companies.

The size effect is calculated from the stock exchange capitalization. A company which has a lower capitalization than the average capitalization of the total sample is considered as a small size company and vice versa.

For the book to market effect, we use a ratio that compares the book value of a firm to its market value. Book value is calculated from the firm's historical costs, or an accounting value. Market value is determined in the stock market through its market capitalization.

For liquidity we apply a measure of Amihud (2002). According to this author, the illiquidity of an action I for one month T is measured by the following formula:

$$ILLIQ_t^i = \frac{1}{N_t^i} \sum_{d=1}^{N_t^i} \frac{|R_{d,t}^i|}{V_{d,t}^i} \quad (1)$$

Where $R_{d,t}^i$: return on stock i in the day d of the month t, $V_{d,t}^i$: Trading volume of stock i in the day d of the month t, N_t^i : A number of days of transaction of stock i in the month t.

The subdivisions of our total samples to sub samples according to these criteria can be presented by the following table:

Table 1: Data statistics

	Name in English	Sector		Size		Book-to-market		Liquidity	
		Banking	Non-banking	Big	Little	Big	Little	Liquid	Illiquid
AB	AmenBan	✓		✓		✓			✓
ATB	Arabic Tunisian Bank	✓		✓		✓		✓	
BH	Habitat Banks	✓		✓		✓		✓	
BIAT	International Arabic Tunisian Bank	✓		✓			✓	✓	
BNA	Agricultural National Bank	✓		✓		✓		✓	
BS	South Bank	✓		✓			✓	✓	
BT	Tunisian Bank	✓		✓			✓	✓	
UBCI	Union Trade Industrial Banks	✓		✓			✓		✓
UIB	International Union Banks	✓		✓			✓	✓	
STB	Tunisian Company Banks	✓		✓			✓	✓	
AMS	Metal Workshop Sahel		✓		✓		✓		✓
ASTR	Reinsurance and Insurance Company		✓		✓	✓			✓
ICF	Chemical Industries of Florine		✓		✓	✓			✓
ATL	Arab Tunisian Lease		✓		✓	✓			✓
CIL	International Company of Leasing		✓		✓	✓			✓
MONOPRIX	Company New House of the Town Tunis		✓		✓		✓	✓	
SFBT	Refrigerating Company and Brewery Tunis		✓		✓		✓	✓	
SOTETEL	Tunisian Company of Telecommunication		✓		✓	✓			✓
TAIR	Tunis Airlines		✓	✓		✓		✓	
SOTUVER	Tunisian Company of Glass Makings		✓		✓	✓			✓
TOTAL		10	10	11	9	11	9	11	9

This table summarizes constituent firms of our sample and its divisions according to activity sector, size, book to market and liquidity criteria.

3. Determinants of abnormal returns in the emergent markets: cross-sectional study

Fama (1998) declares that the ACAR (Average Cumulated Abnormal Returns) is sensitive to several criteria. In this respect, we use various criteria, to give more homogeneity to the sample. Barber and Lyon (1997) assert that the study of the existence of abnormal returns is more influenced by activity sector of firms. They demonstrate that, when we subdivide the sample by sector, the empirical validation to detect abnormal returns is more difficult. On the other hand, when we use simply four groups, the general results remain un-

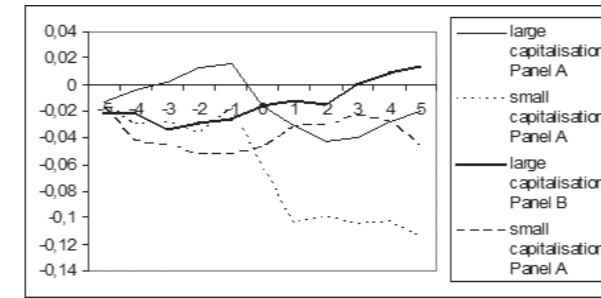
changed. Within the framework of our study, we employ risk effect, size effect, book to market effect and liquidity effect.

3.1. Abnormal return and size effect:

The size effect stipulates that there is a difference between reaction of investors for companies of big sizes and to those of small sizes. This discrepancy, which has no explanation for fundamentalists, presents an abnormality for financial markets. The finding of this abnormality goes back up to decades (Fama and Macbeth (1973)). Banz (1981) reveals the size effect on the New York Stock Exchange during period from 1926 to 1975. His results show that adjusted returns for risk of

Table 2: Abnormal returns and size effect

Panel A								
Large Capitalizations					Small Capitalizations			
	ACAR	T-Stat	T-Sign	T-Rang	ACAR	T-Stat	T-Sign	T-Rang
-5	-0,0133	1,9064	7,7500	1,6503	-0,0134	0,8938	5,3079	0,8144
-4	-0,0040	0,7870	-8,0000	0,8878	-0,0300	1,0957	3,8335	0,9352
-3	0,0015	0,7842	-1,7500	0,8231	-0,0288	0,1240	-3,2437	0,1395
-2	0,0129	1,6849	-7,7500	1,7848	-0,0365	0,6663	4,7181	0,6538
-1	0,0155	0,4515	-5,2500	0,4693	-0,0183	2,6005	-6,7823	1,6582
0	-0,0161	4,1968	8,0000	4,0320	-0,0614	3,9523	5,6028	4,1794
1	-0,0317	2,8419	7,7500	1,8108	-0,1046	3,4188	5,3079	2,9429
2	-0,0422	1,4547	2,0000	1,3329	-0,0999	0,3635	-6,1926	0,3651
3	-0,0395	0,4184	-7,7500	0,4091	-0,1053	0,4525	4,7181	0,4132
4	-0,0279	1,4858	-8,0000	1,5978	-0,1031	0,2187	-3,8335	0,2231
5	-0,0196	1,3047	-4,7500	1,3078	-0,1137	1,3052	5,5156	1,2100
Panel B								
Large Capitalizations					Small Capitalizations			
	ACAR	T-Stat	T-Sign	T-Sk-Aj	ACAR	T-Stat	T-Sign	T-Sk-Aj
-5	-0,0216	2,8624	7,2801	2,9196	-0,0176	1,5379	5,3374	1,6343
-4	-0,0223	0,1099	-2,3351	0,1180	-0,0425	1,7373	6,2524	1,8681
-3	-0,0345	1,2536	1,7857	0,9236	-0,0456	0,2367	4,1175	0,2392
-2	-0,0296	0,6998	-3,1593	0,7950	-0,0529	0,6530	2,2875	0,6399
-1	-0,0260	0,6167	-7,2801	0,6011	-0,0529	0,0016	-3,5075	0,0104
0	-0,0160	2,3663	-7,0054	1,3890	-0,0470	0,5122	-6,1721	0,5334
1	-0,0118	0,6065	0,4121	0,6735	-0,0321	2,3908	-6,1721	1,3660
2	-0,0157	0,6397	-4,2582	0,6406	-0,0306	2,1333	4,0119	0,1560
3	-0,0007	2,4074	-7,2801	2,6702	-0,0228	0,4649	-3,0861	0,5160
4	0,0090	1,4084	-7,2801	1,5971	-0,0274	0,4428	-2,1602	0,4456
5	0,0142	0,9337	-0,9615	0,9779	-0,0455	1,5662	4,8414	1,5169



Graphic 1: Abnormal returns and size effect

small sizes firms are significantly superior to those of big sizes firms.

There are several measures to calculate the size. For example, Heaney and al. (2007) calculated the size of companies from the logarithmic of book value, adjusted by the market average. In our study, we select the market capitalization. To classify companies according to the size criterion, we supposed two classes of sizes (large and small capitalization). For each society of the global sample, we calculate its market capitalization during the event month. Then, we calculate the average of the whole sample for every event. Companies, which have a market capitalization lower than the average of the sample, are considered as companies of weak capitalizations. Also, companies capitalization which exceed the average of the sample, indicate that companies are of large capitalizations.

For every class of size, we proceed to the event study based on the methodology of average cumulated abnormal returns, in order to compare the abnormal returns generated by all groups. Results of this methodology are presented in the table 2.

Table 2 presents different results for both panel A and B and for the companies of small and large.

For the group of companies of small capitalizations in panel A, we notice that the reaction of the investors begins from the event date. This reaction is reflected by a strong variation of abnormal returns, with regard to date -1, which reaches the 235.52% value. It stills for date 1 with a 70.36% variation. From date 2, we observe stability in the variation of abnormal returns. The average cumulated abnormal returns of small companies are statistically significant for date -1, 0 and 1. This confirms the obstinacy of abnormal returns, and as a consequence the inefficiency of the BVMT.

For the large companies of in panel A, we notice that the reaction of investors begins from the event date but it continues for date 2. After this date, we notice an upheaval of this reaction and the abnormal returns get back to 0. The average cumulated abnormal returns of these companies are statistically significant for dates 0 and 1. This allows us to conclude that, even for the large companies panel A, this confirms the inefficiency of the BVMT.

In spite of the existence of the average cumulated abnormal returns in both groups of the panel, we notice that there is a strong difference in the level of abnormal returns generated by these two groups. The companies of small capitalizations generate higher abnormal returns, especially from the date of the event. The percentage of the overtaking of the abnormal returns on the companies of small capitalizations with regard to the companies of large capitalizations exceeds the 200% rate for date 1 and 150% for dates 2 and 3.

Contrary to the panel A, both groups of the panel B mark a difference even at the level of the reaction of the investors. For the companies of weak capitalizations, we notice two phases of reaction. The first phase covers the period which precedes the event date. This reaction increases the abnormal returns in negative sense. From the event, the reaction overturns towards the decreases of abnormal returns and the link towards 0. Statistically, abnormal returns are significant for dates 0 and 1.

For large companies, we observe the absence of a significant investor reaction. Even from statistical view, abnormal returns are significant only for the event date. However, we find that the level of the average cumulated abnormal returns, generated by small companies of, is higher than that of large companies. The size effect is more potential for the panel B. Indeed, we find that the percentage of variation of abnormal returns, for both type of companies, reaches the 193,75%, 172,03% and 94,90% value, respectively for dates 0, 1 and 2; and this value increases enormously in the date 3 and reaches the 3157,14% value.

In spite of the differences of reaction between both type of firms in both panel A and B, small size companies always generate higher abnormal returns. This confirms that the size effect can be a determinant of inefficiency of the BVMT.

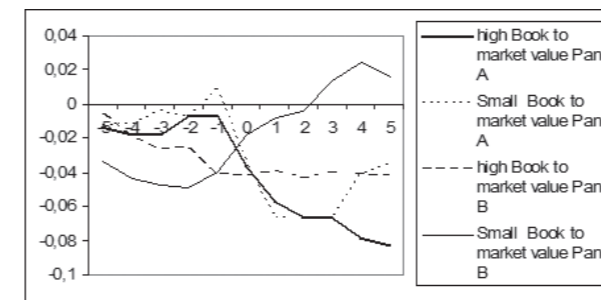
3.2. Book to market effect:

It is well confirmed, in the literature review, that shares returns are influenced by the values of their book to market. Most of the empirical studies show that shares, which have a high book to market value, present higher returns. These results are interpreted by the behavioural polarizations effect. Kothari, Shanken and Sloan (1995), Vassalou and Xing (2004), Griffin and Lemmon (2002) Xiaoquan and Lee (2007), Roychowdhury and Watts (2007) confirm that the book to market effect is stronger for companies with high risk.

In this sub section, we try to verify if the book to market effect can be a determinant of abnormal returns. In that case, we must have a significant change in the level of abnormal returns generated by the companies of small book to market values compared to those of high values. Accepting this hypothesis allows us to consider that the book to market effect presents a determinant of abnormal returns. To do it, we subdivide our sample into two groups. The first group represents the firms with small book to market values and the second group gathers the others. The results of this study are represented in the following table:

Table 3: Abnormal returns and Book-To-Market effect

Panel A								
High Book-To-Market value					Small Book-To-Market value			
	ACAR	T-Stat	T-Sign	T-Rang	ACAR	T-Stat	T-Sign	T-Rang
-5	-0,0138	1,4440	-0,2722	1,2962	-0,0128	1,1283	7,2161	1,0000
-4	-0,0183	0,2976	-0,8165	0,2707	-0,0116	0,1123	-6,6815	0,1627
-3	-0,0180	0,0288	-6,8041	0,0493	-0,0045	1,1468	-0,8018	1,1862
-2	-0,0071	1,1520	-2,7217	1,1915	-0,0083	0,4669	-4,0089	0,4264
-1	-0,0065	0,0694	-0,2722	0,0799	0,0090	2,1682	-4,5434	2,3928
0	-0,0367	3,3257	5,4433	3,3554	-0,0334	4,8190	7,4833	4,7962
1	-0,0575	1,9940	2,7217	1,9099	-0,0667	3,4226	7,2161	2,4996
2	-0,0656	0,8214	5,9876	0,8335	-0,0671	0,0386	0,0000	0,0249
3	-0,0666	0,1241	4,8990	0,1329	-0,0674	0,0363	-5,3452	-0,0170
4	-0,0782	1,1773	5,7155	1,2596	-0,0412	3,7749	-7,4833	4,2056
5	-0,0834	0,6571	0,2722	0,6231	-0,0350	0,9865	-4,0089	1,0097
Panel B								
Large Capitalizations					Small Capitalizations			
	ACAR	T-Stat	T-Sign	T-Rang	ACAR	T-Stat	T-Sign	T-Rang
-5	-0,0061	0,5705	2,8868	0,5884	-0,0339	4,6719	6,9282	4,6338
-4	-0,0189	0,9803	5,4848	1,0218	-0,0441	1,4807	-0,5774	1,4266
-3	-0,0267	0,5775	2,5981	0,5198	-0,0474	0,4938	1,1547	0,5205
-2	-0,0257	0,0924	-1,7321	0,1001	-0,0493	0,3094	0,5774	0,3139
-1	-0,0415	1,4601	5,4848	1,4471	-0,0393	2,3319	-6,9282	2,5923
0	-0,0423	2,0775	-1,4434	2,0953	-0,0183	3,0431	-6,6395	3,3059
1	-0,0385	0,3773	0,0000	0,3863	-0,0082	2,4956	-1,1547	2,6385
2	-0,0435	0,6145	5,4848	0,6029	-0,0042	2,4542	-6,9282	2,5127
3	-0,0392	0,2981	-2,8868	0,3545	0,0135	2,3232	-6,9282	2,3583
4	-0,0418	0,2547	-6,3509	0,2740	0,0243	1,7670	-6,9282	1,8548
5	-0,0422	0,0396	5,1962	0,0436	0,0160	1,1579	0,8660	0,9714



Graphic 2: Abnormal returns and Book-To-Market effect

Table 3 represents different results for both panel A and B and for the companies of high and small book to market.

For the panel A, we notice that there is no difference in reactions for the two types of companies. For both groups, the reaction of the investors begins in the event date. It is proportionally strong and reaches, in term of percentages, 464,62% for companies of high book to market values, and 471,11% for companies with weak book to market values, compared to date -1. For the companies of high values book to market, this reaction continues until dates 1 and 2, with a respective variation of 56,68% and 14,09% with regard to the previous date.

On the other hand, for the companies of weak book to market values, the reaction persists only for date 1 with a variation of 99,70 compared to date 0. From this date, the reaction is almost null (0,60% and 0,45% respectively for dates 2 and 3).

Statistically, abnormal returns are significant for companies of high s book to market value, for dates 0 and 1, and dates -1, 0 and 1 for the other companies. This result confirms the inefficiency of the BVMT for both groups. Concerning our main objective, the panel A presents no difference in reactions according to the book to market criterion. The variation of the average cumulated abnormal returns between both types of firms is small. We find that for companies of high book to market values, the returns exceed those of other companies for dates -5, -4, -3, 0 with the respective percentages 7,25%, 36,61%, 75,00%, 8,99%; and vice versa for dates -2, 1, 2 with respective percentages 16,90%, 16% and 2,29%.

For panel B, the results are contradictory between the two groups. For the group of high book to market

values, the effective reaction begins from date -1 with a negative variation of the average cumulated abnormal returns by 61,48% compared to date -2. This variation continues until the event date with a small variation of 1,93%. After this date, we notice stability in abnormal returns. Whereas the average cumulated abnormal returns are significant only for the event date.

This result contradicts the previous ones concerning the inefficiency of the BVMT. Contrary to companies of high book to market values, other companies record a positive variation of average cumulated abnormal returns. This reaction begins at the date -1 and still until the date 3 with respective percentages: 20,28%, 53,44%, 55,19%, 48,78% et 421,43%. So, the average cumulated abnormal returns are significant for the interval [-1, 3]. Companies of small book to market values confirm the inefficiency of the BVMT.

For the level of abnormal returns generated by both groups, it is clear that companies of high book to market values generate greater abnormal returns. This level is superior from date -1 and still a long the event window. The percentage of overtaking the level of abnormal returns for companies with high book to market values compared to other companies reaches the values: 5,30%, 56,74%, 78,70%, 90,34%, 134,44%, 158,13% and 137,91% respectively for dates -1, 0, 1, 2, 3, 4 and 5.

This study confirms that companies with high book to market values generate abnormal returns superior to those generated by companies of small book to market value. However, this confirmation is stronger for panel B than panel A. This allows us to conclude that the book to market effect can be a determinant of inefficiency of the BVMT.

3.3. Liquidity effect:

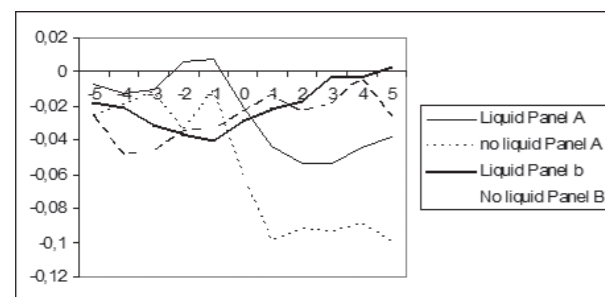
In this sub section, we try to verify if the liquidity effect can be a determinant of the inefficiency of the BVMT (Lesmond (2005)). In this case, we must find a significant change in abnormal returns generated by liquid companies compared to illiquid ones. To classify companies according to liquidity criteria, we use the classification given by the authorities of the Tunisian financial market. We consider the liquid companies those belonging to the group 11 and the illiquid companies those belonging to the group 12. This classification is based on the number of quotation days in such way that

group 11 gathers assets of which the days of quotation vary between 75% et 100% and group 12 includes the others.

The results of this study are represented in the following table 4:

Table 4: Abnormal returns and Liquidity effect

Panel A								
Group 11				Group 12				
	ACAR	T-Stat	T-Sign	T-Rang	ACAR	T-Stat	T-Sign	T-Rang
-5	-0,0068	0,8783	0,2357	0,8366	-0,0259	1,6482	5,8400	1,3839
-4	-0,0127	0,5467	4,9497	0,4618	-0,0192	0,3769	-6,1644	0,4427
-3	-0,0108	0,2863	-4,7140	0,3104	-0,0124	0,6872	-3,2444	0,7138
-2	0,0057	2,4834	-8,4853	2,8123	-0,0340	1,8024	0,9733	1,6393
-1	0,0075	0,2662	-5,6569	0,2697	-0,0111	2,0400	-2,5955	2,2600
0	-0,0218	3,4489	8,4853	3,4233	-0,0611	6,0067	6,1644	5,2960
1	-0,0436	2,8418	8,4853	3,0089	-0,0986	2,4323	2,9200	2,0473
2	-0,0535	1,2311	5,6569	1,1980	-0,0920	0,5074	-2,9200	0,5083
3	-0,0537	0,0234	-4,7140	0,0224	-0,0939	0,1313	-0,9733	0,1016
4	-0,0444	1,6437	-8,2496	1,6493	-0,0893	0,3079	-6,1644	0,3264
5	-0,0386	0,8950	-7,4767	0,8597	-0,0990	1,2253	3,8933	1,2016
Panel B								
Large Capitalizations				Small Capitalizations				
	ACAR	T-Stat	T-Sign	T-Rang	ACAR	T-Stat	T-Sign	T-Rang
-5	-0,0176	2,0267	7,6200	2,1754	-0,0258	2,8366	5,8310	2,5835
-4	-0,0214	0,3721	-2,7940	0,3898	-0,0495	2,5728	3,0870	2,3117
-3	-0,0312	0,9439	4,3180	0,8392	-0,0464	0,3122	0,3430	0,3199
-2	-0,0367	0,8258	0,2540	0,7556	-0,0353	0,8724	-3,4300	0,9377
-1	-0,0408	0,6566	-2,2860	0,5752	-0,0339	0,1126	-5,1450	0,1156
0	-0,0291	2,5241	-7,8740	2,5071	-0,0240	2,8865	3,4300	2,9751
1	-0,0225	1,9619	2,0320	2,0262	-0,0133	2,8950	4,4590	2,8861
2	-0,0175	0,6992	-7,8740	0,7564	-0,0241	1,0646	3,7730	1,0858
3	-0,0028	1,2854	-7,8740	1,4484	-0,0183	0,6101	-5,8310	0,6074
4	-0,0034	0,0741	-4,5720	0,0939	-0,0042	1,5569	-5,8310	1,5875
5	0,0026	0,8895	-4,3180	0,8880	-0,0264	2,0091	2,7440	1,8409



Graphic 3: Abnormal returns and Liquidity effect

For liquid companies in panel A, the investors' reaction begins from date 0 and continues until dates 1 and 2. In term of variation in abnormal returns, the date 0 records the highest level of variation which reaches a 390,67% value with regard to date -1. This variation of the average cumulated abnormal returns continues for dates 1 and 2 with a respective variation of 100% compared to date 0 and 22,71% with regard to date 1. From date 3, we notice the stability in the returns' reaction. For dates 0 and 1, they are statistically significant. We

conclude that liquid companies of panel A confirm the inefficiency of the BVMT.

For illiquid companies in panel A, the reaction of average cumulated abnormal returns begins from date 0 and continues only for date 1. The variation in reaction reaches its maximal value in the date 0 with a percentage value equal to 450,45% compared to date -1. This variation remains proportionally strong in the date 1 and takes a 61,37% value with regard to date 0. From date 2, we observe stability in the average cumulated abnormal returns. They are statistically significant for dates 0 and 1. This result confirms that for illiquid companies in group A, the BVMT is inefficient.

Concerning the variation average cumulated abnormal returns recorded by the liquid companies, with regard to illiquid ones, we notice that illiquid companies register higher abnormal returns than the others. This superiority reaches 696,49% for date -2, continues during the event window and sets respectively for dates -1, 0, 1, 2, 3, 4, 5 the values: 248,00%, 180,28%, 126,15%, 71,96%, 74,86%, 101,13%, 156,48%. These high percentages assert that the lack of liquidity of some stocks can be at the origin of the high level of abnormal returns and as a result of the inefficiency of the BVMT.

For panel B, the average cumulated abnormal returns by liquid companies pass by two phases:

- The first phase begins from date -4 and continues until date -1. This phase is characterized by the increase of the average cumulated abnormal returns in the negative sense. The returns variation is 21,59%, 45,79%, 17,63% and 11,17%, in the negative sense, respectively for dates -4, -3, -2, and -1, with regard to the previous date.
- The second phase begins from date -1 and continues until date 3. During this phase, we notice the weakening of the curve of average cumulated abnormal returns towards the X-axis (i.e. towards the cancellation of the existence returns). This reversal records a constant rhythm for dates 0, 1 and 2, that is a variation of the abnormal returns of 20%.

However, during these periods, abnormal returns remain existing. The great variation during the second phase is registered during the date 3. It reaches 84,00% with regard to date 2. This variation allows the cancellation of the existing abnormal returns. These last ones remain almost nulls for the remainder event window.

From statistical view, the average cumulated abnormal returns are significant for dates 0 and 1. This confirms the inefficiency of the BVMT for liquid firms in group B.

For illiquid companies, the curve of average cumulated abnormal returns registers almost a same variation sense. The date 4 records the highest level of abnormal returns in negative sense. Then, the curve of the abnormal returns turns toward the X axis and it links to 0 in date 4. The average cumulated abnormal returns are statistically significant for dates -1, 0 and 1. This result confirms the inefficiency of the BVMT for illiquid companies in panel B.

For the variation of average cumulated abnormal returns registered by the liquid companies with regard to illiquid firms, we notice that these last ones register abnormal returns proportionally higher than the others. This superiority reaches 553,57% in date 3. These high percentages prove that the lack of liquidity of certain stocks can be at the origin of the high level of abnormal returns, and as a result of the inefficiency of the BVMT.

4. Abnormal return and extension fundamentals models in emergent market

In previous section, we validate three determinants of the inefficiency of the BVMT, namely: size effect, book to market effect and liquidity effect. In this stage, we try to verify if the fundamental models adjusted for these factors of the inefficiency can remedy to the existence of abnormal returns, and as a consequence to explain the dynamics of the shares' prices on the BVMT.

So, we use the same methodology of the event study as presented in the first section. Except that we employ the fundamental models adjusted for the determinants of inefficiency of the BVMT to calculate the normal return.

We study, in what follows, three models. The first is the model of Fama and French (1993) of three factors, which represents a fundamental model adjusted for the size and book to market effects. The second is the model of Acharya and Pederson (2005) which represents a fundamental model adjusted for risk of liquidity. Finally, we use a multi-criteria model which merges both models cited before.

4.1. Abnormal return and market line with GARCH (1,1) risk

The abnormal return is defined as the difference between the observed and the theoretical returns. This last one represents the return in the absence of any event. In the first stage, we used the model of market initiated by Fama, Fischer, Jensen and Roll (1969). The main limit of this model is that it considers variance as constant in time. In other words, the arrival of new information does not modify the risk of the concerned stock. Ohlson and Penman (1985) and David (1987) put in evidence the modification of returns' variance the distributions of shares.

Consequently, we reject in this section, the hypothesis of independence of variance towards time, by introducing a GARCH modelling. This latter allows as calculating, for every date t of the event window, a variance which will take into account the impact of the information.

In order to take into account the evolution of the volatility in time, we use a modelling GARCH (1,1). The choice of the model GARCH (1,1) as determinant of historic return does not imply that we specify the non linearity on the BVMT, but rather to bring to light the impact of the non linearity as the determinant of the risk. However, the specification of the non linearity of the quote on the BVMT will be determined with more details in the sixth chapter.

The model GARCH (1,1) consists of two equations: the first one is the equation of the average, based on the market model. And the second one is the equation of conditional variance.

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_t \quad (2)$$

The variance is dependent in time; its equation is:

$$\delta_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \delta_{t-1}^2 \quad (3)$$

The normal or theoretical return is given by the following equation:

$$Normal\ returns = \hat{\alpha}_i + \hat{\beta}_i R_{mt} \quad (4)$$

The parameters α and β are estimated, for each stock and each event, by the method of the maximum likelihood outward the event window. The use of the GARCH (1,1) allows as supposing that the variance is not constant in time, and consequently the risk of the stock

modifies with the arrival of the new event. The calculation of the statistics of Student takes into account the evolution of volatility. Let us note T the statistics of the test of the abnormal returns, the calculation is established by the follow relation:

$$T_{it} = \frac{RA_{it}}{\delta_{it}} \quad (5)$$

The variance is measured for the entire event window by this equation:

$$\delta_{it}^2 = \hat{\alpha}_0 + \hat{\alpha}_1 RA_{i,t-1}^2 + \hat{\beta}_1 \delta_{i,t-1}^2 \quad (6)$$

The parameters result from the estimation of the model GARCH (1,1) outward the event window. Under the null hypothesis, the statistics T follows a reduced centred normal distribution.

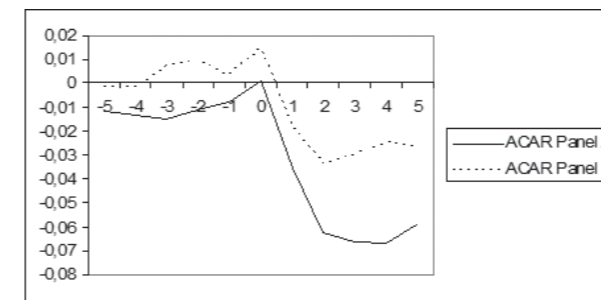
In this stage, the reduction of the abnormal returns with regard to the first study shows that a part of the inefficiency of the BVMT, according to the fundamental principles, is explained by the existence of a non linearity. This will be taken into account during the remainder of our search and especially in construction of the environment of the BVMT.

The results of the event study, based on security market line with GARCH (1, 1) volatility, bring us to two remarks:

1. The level of average cumulated abnormal returns decreases with regard to the study of event based on

Table 5: ACAR and Security Market Line with GARCH (1,1) Volatility

	Panel A		Panel B	
	ACAR	T-Stat	ACAR	T-Stat
-5	-0.012	0.528	-0.0018	0.215
-4	-0.0133	0.6452	-0.0021	0.3574
-3	-0.0149	0.7698	0.0068	1.0916
-2	-0.0112	0.6579	0.0095	0.4663
-1	-0.0077	0.5475	0.0034	0.9305
0	0.0013	1.5670	0.0146	1.7362
1	-0.0350	3.7639	-0.0181	4.5048
2	-0.0622	2.7144	-0.0339	2.1528
3	-0.0663	2.0003	-0.0299	1.6468
4	-0.0670	1.2109	-0.0246	0.7997
5	-0.0594	1.2299	-0.0264	0.2620



Graphic 4: ACAR and Security Market Line with GARCH (1,1) Volatility

security line of the standard market. This decrease allows us to confirm the variation of the volatility on the event window. This result supposes that average cumulated abnormal level of returns, issued from the even study based on security market line, is due to econometric problems concerning the non stability of the systematic risk on the event window. However, this weakness does not imply the non-existence of abnormal returns.

2. In spite of the improvement of event study methodology, by taking into consideration the variation of the systematic risk within the event window, average cumulated abnormal returns remain existing and significant for both panels. This allows us

to conclude that ACAR are far from being owed to problems of linearity of abnormal returns and to problems of stability of the systematic risk within the window of the study of event.

4.2. Abnormal return and Fama French three factors model

To take into account the size and book to market effect as determinant of the inefficiency of the BVMT, we proceed in this sub section to the model of Fama and French (1993) which appears as follows:

$$r_{it} - r_{ft} = \alpha_i + \beta_{1i} (r_{it} - r_{ft}) + \beta_{2i} SMB_t + \beta_{3i} HML_t + \varepsilon_{it} \quad (7)$$

In this model, the average excessive returns of stock are explained by the risk prim of the market. To which are added two factors called SMB (Small capes Minus Big capes) and HML (High B/M Minus Low B/M). These two risk factors are considered as abnormalities on financial markets.

Before going to verify if this model allows us to cancel the existence of abnormal returns, we check the significance of size and book to market effects in the Tunisian context. To do it, we build two portfolios (P1 and P2). The first portfolio represents companies belonging to the banking sector, and the P2 represents the other companies. The results of this estimation are represented in the following table:

Table 6: Model of Fama and French with three factors

Bêta i	Coefficient	Panel A: BVMT Index		Panel B: Tuneindex	
		P1	P2	P1	P2
Bêta 1	Value	0.452992	0.736239	0.739715	1.064788
	t*	7.150794*	10.19035*	13.09162*	16.62109*
Bêta 2	Value	0.351075	-2.61E-01	1.46E-01	-5.56E-01
	t*	4.104521*	-2.678327*	2.287479*	-7.669195*
Bêta 3	Value	-0.037758	-0.028983	-0.118822	-0.13422
	t*	-0.522521	-0.351675	-2.240071*	-2.231764*

* Design significance at 5%

The reading of results in table 6 shows that:

1. The systematic risk is statistically significant for both panels (A and B) and for both portfolios (P1 and P2). However, we notice that the coefficient of the systematic risk of non banking companies is higher than other. This allows us to conclude that

non banking companies are more sensitive to the systematic risk.

2. The coefficients of size effect are statistically significant for both panels and both portfolios. However, we notice that, for both panels, the coefficient of size effect of banking companies is positive. On the

other hand, it is negative for the non banking ones. This result confirms our finding in cross sectional study of this effect. In this stage, we validate that the small companies generate abnormal returns higher than those of the large sizes. Knowing that, on the BVMT, the sample of big sizes firms consists generally of banking companies, we can interpret the phenomenon according to which the size effect represent a positive effect for the banking companies, on the other hand it is negative for the other ones.

3. The third effect in the model of Fama and French (1993) is the book to market effect. We notice that, for this effect, there are two contradictory results between groups A and B. For the panel B, this coefficient is significant; but it is not for group A. For both groups, book to market effect presents a negative coefficient, which implies that this effect

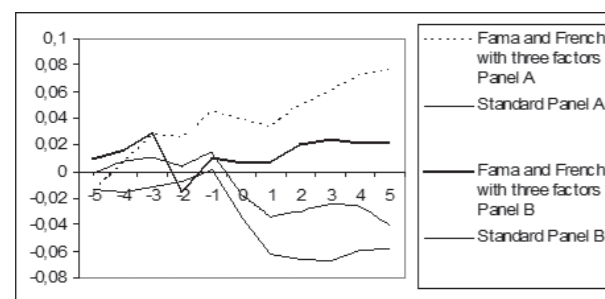
influences negatively the returns. This result also confirms our finding in the cross sectional study in two criteria. In this latter, we validate that the size effect is more potential than the book to market effect. This confirmation is due to the stability of the significance of size effect coefficients both groups and for both portfolios, and in the instability of the significance of the book to market effect.

These results allow us to pass to the following stage: “to verify if integrating the two effects in the explanation of the dynamics of stock prices, permit to explicate and cancel the existence of abnormal returns generated by standard fundamental models”. To do that, we adopt the same methodology of event study, used in first section. Except, we suppose that the normal return is calculated with of Fama and French with three factors model. The results of this study are presented in the following table:

Table 7: Abnormal returns and the model of Fama and French with three factors

	Panel A			Panel B		
	Fama and French with three factors	T-Statistic	Standard	Fama and French with three factors	T-Statistic	Standard
-5	-0,01476	0.2246	-0,01332	0,00941	0.2453	-0,00210
-4	0,00665	1.5471	-0,01486	0,01690	1.2929	0,00676
-3	0,02652	1.3765	-0,01115	0,02903	1.0884	0,00954
-2	0,02501	1.2345	-0,00774	-0,01502	1.7654	0,00342
-1	0,04484	1.9891*	0,00134	0,01016	2.4438*	0,01457
0	0,03873	2.3421*	-0,03504	0,00648	2.6547*	-0,01811
1	0,03372	1.0745	-0,06218	0,00731	1.9691*	-0,03386
2	0,04988	0.9546	-0,06633	0,02077	1.6697	-0,02989
3	0,05944	0.7876	-0,06702	0,02389	1.3543	-0,02457
4	0,07181	1.6456	-0,05936	0,02108	0.3276	-0,02637
5	0,07532	0.2203	-0,05887	0,02205	0.2314	-0,04091

* Design significance at 5% level



Graphic 5: Abnormal returns and the model of Fama and French with three factors

The results of the event study based on the model of Fama and French with three factors, show that there is an upheaval in sign of abnormal returns. Indeed, it is negative, and then it becomes positive, according to the model of Fama and French.

This means that, considering existing abnormalities in the market as those of size and the book to market effects (within the framework of our model), investors' expected returns will be much less with regard to those

in case of efficient market. This decrease provokes the positive sign of abnormal returns.

In term of absolute values, we notice that the abnormal returns issues from the security market line and those stemming from the model of Fama and French with three factors are competing. It implies that investors' reaction and abnormal returns remain existing. Thus, even when we consider both determinant of inefficiency of the BVMT (size and effect book to market effects), abnormal returns remain existing and significant. So, the model of Fama and French with three factors is inept to remedy the existence of the abnormal returns.

4.3. Abnormal return and CAPM- Adjusted for liquidity risk:

The empirical studies on the microstructure of financial markets generally demonstrate that the liquidity is risked on these markets. It changes in time, either for individual stocks, or for the whole market. This report urges certain authors to assert that challenge on financial markets does not result from the problem liquidity level, but from the variation of this level in the time. This makes investors in uncertainty, i.e. in a risky situation.

To validate the effect of risk liquidity on the degree of market efficiency, we use the adjusted CAPM for risk liquidity proposed by V. L.H Acharya and. Pedersen (2005). The authors suppose that the expected stock return, within the framework of the standard CAPM, must be increased by a prim illiquidity risk. Their model stipulates three types of liquidity risks:

1. The risk of stock liquidity with regard to market;
2. The sensibility of sock return with regard to market liquidity;
3. The sensibility of stock liquidity with regard to market return.

To measure the illiquidity, they use the measure of Amihud (2002). The model is formulated as follow:

$$E_t(r_{t+1}^i - c_{t+1}^i) = r^f + \lambda_t \frac{\text{cov}_t(r_{t+1}^i - c_{t+1}^i, r_{t+1}^M - c_{t+1}^M)}{\text{var}_t(r_{t+1}^M - c_{t+1}^M)} \quad (8)$$

Where:

$$\lambda_t = E_t(r_{t+1}^M - c_{t+1}^M - r^f)$$

is the prim risk.

The development of the first equation gives:

$$E_t(r_{t+1}^i) = r^f + E_t(c_{t+1}^i) + \lambda_t \frac{\text{cov}_t(r_{t+1}^i, r_{t+1}^M)}{\text{var}_t(r_{t+1}^M - c_{t+1}^M)} + \lambda_t \frac{\text{cov}_t(c_{t+1}^i, c_{t+1}^M)}{\text{var}_t(r_{t+1}^M - c_{t+1}^M)} - \lambda_t \frac{\text{cov}_t(r_{t+1}^i, c_{t+1}^M)}{\text{var}_t(r_{t+1}^M - c_{t+1}^M)} - \lambda_t \frac{\text{cov}_t(c_{t+1}^i, r_{t+1}^M)}{\text{var}_t(r_{t+1}^M - c_{t+1}^M)} \quad (9)$$

This model asserts the first advanced opinion, because the expected stock return must be increased by a prim risk of illiquidity. Moreover, this model forecasts four risks supported by the expected stock return. In addition to the standard CAPM risk, that represents the covariance between stock return and market return, the adjusted CAPM to liquidity stipulate three other forms of risk caused by liquidity.

$$E(r_t^i - r_t^f) = E(c_t^i) + \lambda_t \beta^{1i} + \lambda_t \beta^{2i} - \lambda_t \beta^{3i} - \lambda_t \beta^{4i} \quad (10)$$

Where:

$$\lambda_t = E_t(r_{t+1}^M - c_{t+1}^M - r^f)$$

$$\beta^{1i} = \frac{\text{cov}(r_t^i, r_t^M - E_{t-1}(r_t^M))}{\text{var}(r_t^M - E_{t-1}(r_t^M) - [c_t^M - E_{t-1}(c_t^M)])}$$

$$\beta^{2i} = \frac{\text{cov}(c_t^i - E_{t-1}(c_t^i), c_t^M - E_{t-1}(c_t^M))}{\text{var}(r_t^M - E_{t-1}(r_t^M) - [c_t^M - E_{t-1}(c_t^M)])}$$

$$\beta^{3i} = \frac{\text{cov}(r_t^i, c_t^M - E_{t-1}(c_t^M))}{\text{var}(r_t^M - E_{t-1}(r_t^M) - [c_t^M - E_{t-1}(c_t^M)])}$$

$$\beta^{4i} = \frac{\text{cov}(c_t^i - E_{t-1}(c_t^i), r_t^M - E_{t-1}(r_t^M))}{\text{var}(r_t^M - E_{t-1}(r_t^M) - [c_t^M - E_{t-1}(c_t^M)])}$$

1. The first risk is similar to that of the systematic risk of the standard CAPM.
2. The second risk stipulates that the expected return increases with the covariance between the lack of stock liquidity and lack of market liquidity. This effect is explained by the fact that the investor wants to reward the lack of stock liquidity when the market is illiquid. Thus, the second beta represents the prim risk for which the investor agrees to hold or to buy an illiquid stock in an illiquid market. This phenomenon is empirically demonstrated by Chordia and al. (2000), Hasbrouck and Seppi (2001).
3. The third effect on the return is represented by the covariance between the stock return the market il-

liquidity. This covariance affects negatively the expected return. This is due to the fact that investors must accept an inferior expected stock in a market which misses liquidity. This phenomenon is empirically demonstrated by Pastor and Stambaugh (2003), Sadka (2002) and Wang (2002).

4. The fourth and last risk is represented by the covariance between the lack of stock liquidity with regard to market return. This covariance influences negatively the expected return by the fact that the investors accept a lower expected return, although for a liquid stock in a generally overdrawn market. This risk shows that stock liquidity, in an overdrawn market, becomes a cost of illiquidity. This phenomenon was put in evidence by Lynch and Bronzing (2003).

Within the framework of our study, we are interested in the restricted version of this model proposed by Acharya and L.H. Pedersen (2005). This model spells under the following shape:

$$r_t^i = r_t^f + c_t^i + \beta_{1i} (r_t^m - r_t^f - c_t^m) \quad (11)$$

With:

r_t^i : Return of stock i in month t

r_t^f : Return of risk-free asset in month t

r_t^m : Market return in month t

c_t^i : Innovation of illiquidity of stock i in the month t.

This measure is equal to the difference between the measure of illiquidity of stock i in the month t and the expected illiquidity.

c_t^m : Innovation of illiquidity of the market in the month t. This measure is equal to the difference between the measure of market illiquidity in the month t and the expected illiquidity.

For the measure of the illiquidity, they use the measure of Amihud (2002). According to this author, the illiquidity of stock i during a month t is measured by the following formula:

$$ILLIQ_t^i = \frac{1}{N_t^i} \sum_{d=1}^{N_t^i} \frac{|R_{d,t}^i|}{V_{d,t}^i} \quad (12)$$

Where:

$R_{d,t}^i$: Return of stock i in day d of month t

$V_{d,t}^i$: Trading volume on dinars of stock i in day d of month t

N_t^i : Number of trading days of stock i in month t

The market illiquidity in the month t is measured by the following formula:

$$ILLIQ_t^M = \frac{1}{N} \sum_{i=1}^N ILLIQ_t^i \quad (13)$$

N represent the number of the stocks which compose the index of reference that represent the market.

For the measure of expected illiquidity, authors use an auto-regressive modelling of the illiquidity. In our work, we employ a modelling of type AR (2) according to the specification of our data series. Therefore, the expected illiquidity of stock i in the month t is:

$$E(ILLIQ_t^i) = \alpha + \beta_1 ILLIQ_{t-1}^i + \beta_2 ILLIQ_{t-2}^i \quad (14)$$

The market expected illiquidity for month t is:

$$E(ILLIQ_t^M) = \alpha + \beta_1 ILLIQ_{t-1}^M + \beta_2 ILLIQ_{t-2}^M \quad (15)$$

Before checking the capacity of the model in cancelling the existence of abnormal returns, we are going to verify the significance of the systematic risk adjusted to the risk liquidity in the Tunisian context. The results of this estimation are represented in the table:

Table 8: CAPM adjusted to liquidity risk

	Coefficient	Panel A: BVMT index		Panel B: Tunindex	
		P1	P2	P1	P2
Adjusted beta	Value	0.432456	0.744376	0.953232	0.751017
	T*	6.125703*	10.03256*	11.78273*	12.52123*

* Design significance at 5% level

The reading of estimation results concerning the coefficient of systematic risk adjusted for the liquidity risk, shows that this risk is widely significant for both panels A and B and for both portfolios (the portfolio P1 represents banks P2 gathers non banking companies).

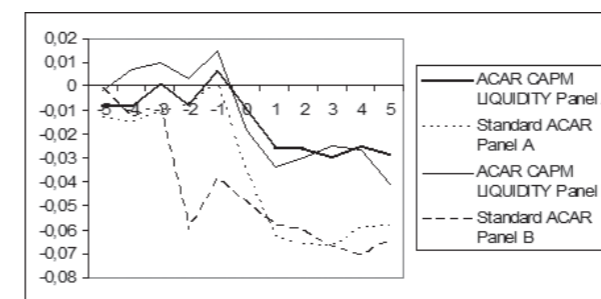
The following step consists in verifying if considering the liquidity risk in explaining prices dynamics can

describe and cancel the existence of abnormal returns generated by the standard fundamental models. So, we adopt the same methodology of event study used on the first section. Except, we suppose that the normal return is calculated by the reduced version of the CAPM adjusted to liquidity risk. The results of this study are presented in the following Table 9:

Table 9: Abnormal returns and adjusted CAPM to liquidity risk

	Panel A			Panel B		
	Standard ACAR	ACAR CAPM Liquidity	T-Statistic	Standard ACAR	ACAR CAPM Liquidity	T-Statistic
-5	-0,01332	-0,00769	0.6012	-0,00070	-0,00210	1.0254
-4	-0,01486	-0,00830	0.7342	-0,01262	0,00676	1.0768
-3	-0,01115	0,00126	1.9887*	-0,00806	0,00954	0.6875
-2	-0,00774	-0,00738	2.0987*	-0,06016	0,00342	1.3093
-1	0,00134	0,00632	2.6754*	-0,03889	0,01457	1.6548
0	-0,03504	-0,00972	2.0342*	-0,04808	-0,01811	1.9938*
1	-0,06218	-0,02537	1.6754	-0,05805	-0,03386	2.2387*
2	-0,06633	-0,02582	0.6718	-0,06018	-0,02989	2.5867*
3	-0,06702	-0,02980	0.5430	-0,06676	-0,02457	1.9783*
4	-0,05936	-0,02454	1.0123	-0,07049	-0,02637	1.6504
5	-0,05887	-0,02905	1.7366	-0,06461	-0,04091	0.4067

* Design significance at 5% level



Graphic 6: Abnormal returns and adjusted CAPM to liquidity risk

The results of the event study based on the model of CAPM adjusted to liquidity risk; show that there is a decrease of abnormal returns with regard to the study based on market model. For panel A, the level of abnormal returns decreased in 50 %, almost over the entire event window. For panel B, we register a strong decrease of this level before the date of event. This

decrease, in term of percentage, reaches the 153,57%, 218,36%, 105,68% and 137,46% respectively for dates -4, -3, - and -1.

From the date of event, abnormal returns decrease just little compared to the event study with market model, and is about 50%. However, abnormal returns remain existing; and investors' reaction continues even after the event date.

Thus, even with the CAPM adjusted for liquidity risk, the BVMT remains inefficient. So we conclude that considering the liquidity effect decrease abnormal returns but can't cancel them. From where, the incapacity of the CAPM adjusted for liquidity risk to remedy the existence of abnormal returns and afterward to explain prices dynamics on the BVMT.

4.4. Abnormal return and multi-criteria model

In order to take into account three determinants of inefficiency of the BVMT, we suppose a multi-criteria mod-

el which merges the model of Fama and French (1993) and the model of Acharya and Pederson (2005). The foundation that we use for the development of our multi-criteria model is the same employed by Acharaya and Pederson (2005) during the passage from standard CAPM to CAPM adjusted for illiquidity risk. In our case, instead of basing on the standard CAPM as point of departure, we go from the model of Fama and French to three factors. The result is from the development and

the formulation of a new relative model, appearing as follows:

$$r_t^i = r_t^f + c_t^i + \beta_{1i} (r_t^m - r_t^f - c_t^m) + \beta_{2i} SMB_t + \beta_{3i} HML_t \quad (16)$$

Before verifying if this model cancels the existence of abnormal returns, we are going to check the significance of the systematic risk adjusted at liquidity risk in the Tunisian context. The results of this estimation are represented in the following Table 10.

Table 10: multi-criteria Modèle

Bêta i	Coefficient	Panel A: BVMT index		Panel B: Tunindex	
		P1	P2	P1	P2
Bêta 1	Value	0.453142	0.736275	0.739887	1.064839
	T*	7.153714*	10.19395*	13.09621*	16.62959*
Bêta 2	Value	0.350768	-0.261389	0.146006	-0.555522
	T*	4.100702*	-2.679968*	2.285366*	-7.67191*
Bêta 3	Value	-0.037868	-2.89E-02	-1.19E-01	-1.34E-01
	T*	-5.24E-01	-3.51E-01	-2.24E-01	-2.22752*

* Design significance at 5% level

The results of this table show that:

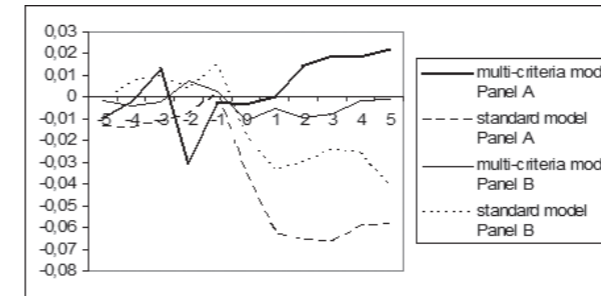
1. The coefficient of the systematic risk adjusted for liquidity risk is positive and significant for both panels and portfolios
2. The coefficient of size effect is significant for both panels. However, this coefficient is positive for banks and negative for the other sector
3. For the coefficient of book to market effect, we notice that it is negative for both panels and portfolios. This coefficient is significant for the group B but not for group A.

The use of this model in the event study gives us the results presented in the following Table 11:

Table 11: Abnormal returns and multi-criteria model

	Panel A			Panel B		
	Multi-criteria Model	T-Statistic	Standard Model	Multi-criteria Model	T-Statistic	Standard Model
-5	-0,00973	1,054	-0,01332	-0,00209	2,654	-0,00210
-4	-0,00251	0,6840	-0,01486	-0,00466	1,7645	0,00676
-3	0,01270	1,0547	-0,01115	-0,00291	1,0186	0,00954
-2	-0,03077	0,7236	-0,00774	0,00706	2,1764*	0,00342
-1	-0,00265	1,3846	0,00134	0,00252	2,4583*	0,01457
0	-0,00384	3,4343*	-0,03504	-0,01085	2,0580*	-0,01811
1	0,00046	2,3548*	-0,06218	-0,00579	2,0792*	-0,03386
2	0,01371	2,2964*	-0,06633	-0,00956	1,0504	-0,02989
3	0,01879	2,1746*	-0,06702	-0,00755	1,2489	-0,02457
4	0,01771	0,3160	-0,05936	-0,00129	1,2935	-0,02637
5	0,02172	0,5735	-0,05887	-0,00077	1,0186	-0,04091

* Design significance at 5% level



Graphic 7: Abnormal returns and multi-criteria model

The multi-criteria model shows similar results with regard to those of the model of Fama and French (1993). We notice an upheaval in sign of abnormal returns, as explained by the model of Fama and French (1993). In term of absolute values, the level of abnormal returns decreases compared to the standard model. However, investors' reaction remains existing and abnormal returns persist for several months after the event date. This confirms the inefficiency of the BVMT and the incapacity of the fundamental models, adjusted for microstructural determinants in explaining the prices dynamics.

5. Conclusion:

We study if extensions of fundamental models adjusted to microstructural determinants, can remedy the existence of abnormal returns. First, we study the microstructural determiners of the inefficiency of the BVMT, by using a cross sectional studies with one and two criteria. The studied criteria are: size effect, book to market effect and liquidity effect. The results of this study with a single criterion show that:

1. There is a significant change in the level of abnormal returns generated by the firms of small capitalizations with regard to those of large capitalizations. Indeed, the firsts generate a higher abnormal returns compared to the seconds. It means that the size effect present a determinant of the inefficiency of the BVMT.
2. There is a significant change in the level of the abnormal returns generated by the companies of big book to market with regard to those of small book to market. We find that firsts generate abnormal returns higher than other ones. It means that the

book to market effect presents a determinant of the inefficiency of the BVMT.

3. There is a significant change in the level of the abnormal returns generated by the liquid companies with regard to those less liquid. It means that the liquidity effect presents a determinant of the inefficiency of the BVMT.

In second, we verify if the fundamental models adjusted for these determinants of the inefficiency can remedy the existence of abnormal returns and afterward, explain the dynamics of the stock prices on the BVMT. To do that, we use the same methodology of the event study presented in the first section. Except, we employ the fundamental models adjusted for the determinant of inefficiency of the BVMT to calculate the normal return.

Finally, we study three models. The first one is the model of Fama and French in three factors which represents a fundamental model adjusted for the size book to market effects. The second is the model of Acharya and Pederson (2005) which represents a fundamental model adjusted for the liquidity risk. And for the third, we use a multi-criteria model which merges both models. The results show the incapacity of the fundamental models to cancel the existence of abnormal returns.

This first part confirms two important points: the incapacity of the theory of the efficiency to explain abnormal returns and the influence of the psychological bias on these last ones.

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Forecasting weekly crude oil freight rates, 1983-2008, using chaotic tools and methods

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In this paper we describe an attempt to forecast the weekly crude oil index (called the ‘world-scale’) for an 80,000 dwt tanker North Africa-Continent using a long-term data set from January 1983 to February 2008. This found a pattern that followed a chaotic time series with low-dimensional (<10) chaos in a deterministic pattern with dependence on initial conditions. We showed the existence of nonlinearity and a biased random walk. There is an “attractor” with “fractal” dimension of just over 5. We needed at least 6 equations to “derive” our time series which can be interpreted as indicating the presence of a low dimensional chaos. The maximum Lyapunov exponent calculated found to be positive and equal to +0.08. The predictions attempted using a relevant software package (NLTSA V.2.0, 2000) and the model of Farmer & Sidorowich, were successful within the sample (12 weekly known values) with estimation errors of 0.52 and 0.6 (in both cases less than unity) using OLS (Ordinary Least Squares Method) and KDE (Kernel Density Estimation Method). An out-of-sample forecast was also made.

Keywords: Crude oil weekly world-scale forecasting, 1983-2008, Tanker 80,000 dw tons, North Africa-Continent, nonlinear chaotic tools and methods

JEL Classification: G14, C22, C53, L92

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Introduction

This paper provides an application, which we consider to be a departure¹ from linear and nonlinear stochastic systems analysis – with short term dependence/correlation – which have been applied to time series data for the last 81 years (Yule, 1927). That tradition is well established and characterized by models such as AR², ARMA³, ARIMA⁴, ARCH⁵, GARCH⁶, EGARCH⁷, and a number of other similar approaches. Our approach, in contrast, however, is related to the models called ARFIMA⁸ and Artificial Neural Networks⁹.

We will use ‘nonlinear dynamic’¹⁰ and ‘chaotic’¹¹ deterministic models to detect long term dependence or memory in the time series. This is based on the argu-

- 1 The unfamiliar reader may first consult any of: Peters (1994), Siroiopoulos C. (1998), Siroiopoulos-Leontitis (2000), Papaioannou (2000) and Mandelbrot & Hudson (2004).
- 2 AR = Auto Regressive process = a stationary stochastic process where the current value of a time series is related to the past p values (p=any integer). An AR (1) process has an infinite memory.
- 3 ARMA = Auto Regressive Moving Average process = a stationary stochastic process that can be a mixed model of AR and MA. MA = a stationary stochastic process in which the observed time series is the result of the moving average of an unobserved random time series.
- 4 ARIMA = Auto Regressive Integrated moving average process = a non-stationary stochastic process related to ARMA.
- 5 ARCH (1982) = an AR with Conditional Heteroskedasticity = a nonlinear stochastic process where the variance is time-varying and conditional upon the past variance, with high peaks at the mean and fat tails. These are models for the analysis of the predictability of variance introduced by Engle, Bollerslev, Nelson and others.
- 6 This means the Generalized ARCH (1986). It refers to a set of statistical tools to model data whose variability changes with time. The changes in variability are controlled by data’s own past behavior and it has been generalized to accommodate more circumstances as a further development of the initial ARCH.
- 7 EGARCH (1991) = Exponential GARCH.
- 8 ARFIMA (1989) = Auto Regressive Fractionally integrated moving average process = an ARIMA (p, d, q) process where d takes a fractional value, as then it can exhibit long memory effects.
- 9 Is a model able to mimic a biological neural system.
- 10 Is a system of nonlinear differential (or difference) equations with time as a main independent variable.
- 11 Is a nonlinear dynamic system producing results that seem to be random characterized by sensitive dependence on initial conditions and the existence of a “strange” (chaotic) “attractor” in its “phase space”. These last concepts are defined below.

ment of Lillekjendlie et al (1994) and Small (2005) that the standard linear modeling and prediction techniques based on ARMA models are not suitable for chaotic systems. Also, as argued by Lillekjendlie et al (1995) prediction of chaotic time series is a totally new branch of science, which does not depend upon the use of the traditional approach of using an autocorrelation function and its related tests.

It is widely accepted that Chaos was first detected in the 1960s in Topology (Smale, 1963) and at the same time in Meteorology (Lorenz, 1963, known by the famous butterfly effect). Later it appeared in Physics (Eckman & Ruele, 1985). Chaos introduced non-periodic and asymmetric cycles, something unknown before. For example, the famous traditional Power Spectrum Analysis of J.B.J.Fourier has been demolished by Takens (1981).

Chaotic systems exhibit sensitivity to the starting (initial) conditions of the system under study, an issue first approached by Poincare (1880) (1860-1934) as mentioned by Zahar¹² (2001). Chaos is not random although it appears to be (Goulielmos, 2001) and it has its own independent variables that describe the motion of a dynamic system. The Chaotic system is not given to us a priori – i.e. in a time series – but it has first to be discovered and then studied in a special (complex) mathematical space. This was cleverly invented for this purpose, presenting negative and positive time around zero (i.e. past, future and present). As Gleick (1990) argued successfully the “phase space”¹³ provided the

12 As shown by Zahar E. (2001), ‘no matter how close to each other two functions might initially be, they could eventually differ from each other in the most unexpected and spectacular manner.

Consider equations for the laws of motion: (1) $f' = d(mv')/dt$

$$f' = d \left[\frac{mv'}{\sqrt{1-v^2/c^2}} \right] / dt$$

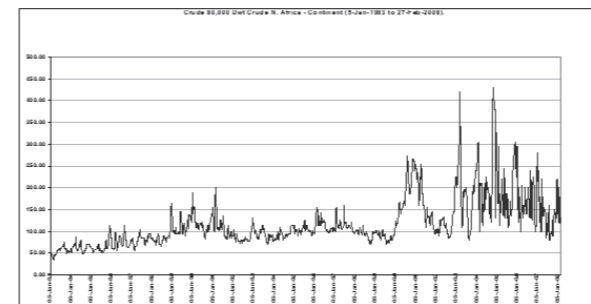
(Newton’s) & (2) (Einstein’s). These two start as being observationally equivalent for small values of (v/c). But near (v/c) =1 they diverge qualitatively from each other in a most dramatic way (F’=field vector, v’=field vector.

13 Is the graph or mapping of all possible situations of a dynamic system or an ‘at the same time’ diagram of the value of a variable against the possible values of all other variables that determine the system. The number of variables determines the dimensions of the phase space. It is a mathematical concept consisting of the space in which coordinates represent the independent variables needed to specify the state of a dynamic system at any time. It

way to transform numbers into pictures presenting the real information of a moving system and creating a road map that shows all its possibilities”.

Our application will be in shipping industry, a heavy user of funds mainly from banks or, to a lesser extent, from stock exchanges (about 30 Greek shipping companies resorted to world stock exchanges for the first time in history). Indeed, between 1997 and 2005 the world economy has provided US \$339 billion to shipping in order to build new ships and buy second hand ones. Of these funds, \$205 billion were paid over a recent three-year period (2003-5). The share of the Greek industry (the leading maritime power in the world) in these funds varied from 43% in 2003 to 93%(!) in 2002 according to the maritime press (end 2007 Shipping Finance Journal). Container ships accounted for \$ 30 billion per year over the last three years and as one shipowner stated “globalization without containerization is not possible”. And all the above funds are offered, as far as we know, without any successful forecasting at all. Indeed, the market fell in 2005-6 to one third of its original value for bulkers (dry cargo – in bulk – carriers) and to 60% for tankers (oil trade), while Clarkson’s shipbuilding price index jumped to 160 in 2005, from a base of 100 in 1999. This industry is very volatile and difficult to predict, even with the use of nonlinear tools. The volatility of the shipping time series can be seen in Diagram 1.1.

Diagram 1.1: Weekly freight rates of 80,000 tons tanker, 1983 (05/01)-2008 (27/02) in ‘world-scale’ index.



Source: Fearnley’s Shipping Research office, Oslo. In vertical axis freight rate index is measured in WS-world-scale- and in horizontal time in weeks.

is constructed from a time series alone. Alternatively a pseudo phase space plot made with the hope of seeing an “attractor”. See below for a definition and graph of the term attractor.

Aim of the paper

Our task is to predict/forecast the weekly oil freight market¹⁴ especially the weekly freight rates (price/rent) over the route from North Africa to the Continent transported by an 80,000 d.w. (dead weight-carrying capacity) tons crude oil tanker vessel.

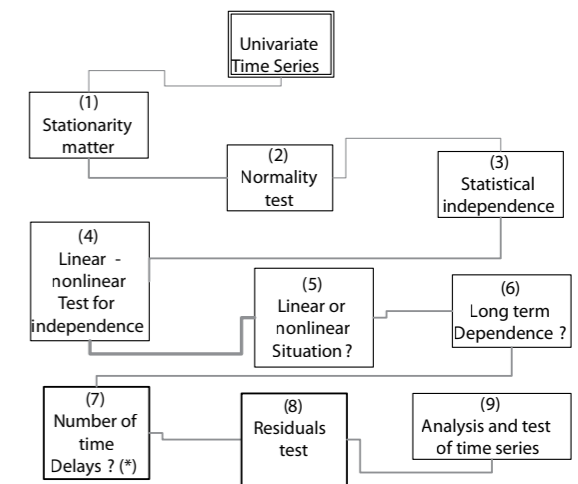
Structure of the paper

First, we provide a description of the methodology used. This is followed by a literature review about forecasting, finance and shipping finance. Next we present the Analysis I & II with specific tools that we have been used and the results we have achieved. The next section contains the main argument of this paper which is predicting within- and forecasting outside-the-sample for the (tanker) index of oil cargo for 12 weeks ahead. The paper ends with a concluding section. In short appendices we present most of our theoretical mathematics.

Methodology plan

In methodology our work flow will be as shown in Diagram 1.2¹⁵.

Diagram 1.2: Our Work flow working with Univariate Time Series.



14 “World-scale” index – first established in its present form in 1983 and revised in 1988 – is a freight rate index (price or rent) for transportation of oil (tankers only). See Laulajainen R & Johansson J, 2006, Worldscale: what does it actually measure?, Maritime Policy and Management Int. journal, No 5, Vol. 33, p. 477.

15 Siroiopoulos (1998, pp. 29 et seq.).

Source: original idea from Siriopoulos.* One of the two widely used methods to reconstruct the phase space (the other is the Singular values decomposition). The main tools used are the delay time, the sampling time and the window length. We use here the concept of the delay vector (Casdagli, 1991).

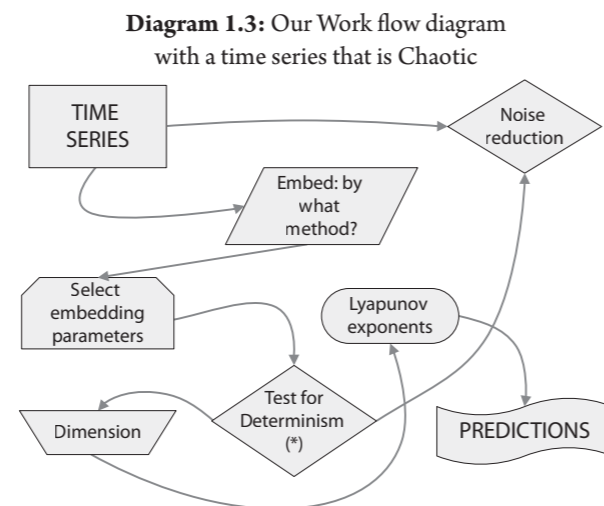
As shown above, we have to deal with a one-single-variable time series (univariate). We have the following steps: (1) to make our time series first *stationary*¹⁶ using a filter (first logarithmic differences or first differences etc, carried out by software MATLAB 5.3 and/or NLTSA V.2.0 mentioned below). The stationary time series does not bring risk and does not retain its variability in time; (2) to test our *stationary* time series for *normality* i.e. to find out what kind of dependence we have; (3) to test for statistical independence, which if rejected means non-linear dependence. In our case, if there is a *nonlinear dependence*, then a *nonlinear* model should be used; (4) to test for long run memory, and if found *then* we can go directly and examine the existence of *Chaotic dynamics*, using the so called 'dimension' approach.¹⁷ (5) The final stage is to approach the space and make our predictions/forecasts using suitable models and software (i.e. NLTSA V.2.0, 2000).

It should be noted that some time series, although stationary, show *persistence*, which means small, but non-negligible dependence on distant observations, where large freight rates are followed by large freight rates and vice versa. The existence of long-term memory in time series can be identified as a more rapid movement away from the starting point than the random walk. This is also a test as to whether the time series is *random*. In the positive long memory test we can use then either the ARFIMA models (due to Diebold

& Rudebusch 1989) or the 'Hurst statistical method', also called the Rescaled Range Analysis, which is the method we use in this paper (due to Mandelbrot 1969 & Hosking 1984).

When we see that we have a chaotic time series our methodology is further supplemented.¹⁸ The target here is to (re)construct¹⁹ a model that it will describe in some sufficient degree the observations of our time series.

Thus, our second work flow chart is shown in Diagram 1.3.



Source: original idea from Siriopoulos-Leontitsis.

(*) If one is able to write down some mathematical rule by which the future state can be determined precisely from the current state at any instance for some value of positive time, then a rule Φ is also deterministic and the dynamical system defined by that rule is also deterministic (Small, p. 3).

Literature review

The famous British statistician Kendal [1953] was the first to dispute the general methods used in forecasting, saying, "The prediction of future prices from past prices is not possible". Despite this, many authors have suggested that the "random walk model" does indeed provide a way of describing the way that prices move, leading to the famous "autocorrelation" in the varia-

tions in prices and moreover to the AR(IMA)²⁰ models pioneered by Yule. In addition, Cootner (1964] found that markets were *effective* because they use all the publicly available information, confirming a random walk model (white noise). A consequence of this is that variations in prices must be independent.

Forecasting freight rates accurately was the dream of many generations of Maritime Economists. Maritime Economics was established in the 1950s (Goulielmos, 2001).

As Stopford (1997:509) stated: "There are many obstacles in producing a worthwhile forecast", even though these forecasts in demand and used by banks, shipping companies, civil servants and consultants (Ibid, p. 500). Stopford (1997, p. 506, 515) is a well known maritime economist who used an extensive, worldwide, 9-stage model. But he argued that when one comes to predict what will actually happen, shipping market models are very blunt instruments.

Moreover, McConville (1999, p. 11-12) argued that too much emphasis is placed on the predictive ability of economic analysis in order to design policies for intervention and influence the freight market mechanisms.

In this paper, as mentioned above, we have used nonlinear methods (Small, 2005, p. 1) from Chaos Theory as a continuation of our research work published/presented previously (Goulielmos-Psifia, 2006, 2007). In fact, one of the authors of this paper was the first to develop Maritime Chaos and Maritime Complexity theory (Goulielmos, 2002, 2004). Other authors have worked along similar lines in the area of Maritime Neural Networks [Li & Parsons, 1997; Lyridis et al, 2005].

In our previous papers we have shown that trip dry cargo freight rates (monthly index) have shown long term memory and a-periodic cycles [Goulielmos-Psifia, 2006, 2007]. As a result, "normal distribution techniques" cannot be used without appropriate prior tests. It was also shown [Goulielmos-Psifia, 2007], through the use of the BDS test²¹ that time and trip freight rate

series are not independently and identically distributed (IID), which is the basic assumption in Gaussian methodology. This rejection of the long celebrated normality was also confirmed by using the Jarque-Bera test. Maritime time series data have shown heavy kurtosis and heavy skewness leading to econometric anomalies (Mandelbrot-Hudson, 2004).

Long run memory and unequal cycles were also detected in the prices of the second hand market for tankers (Goulielmos-Syropoulou, 2006). Forecasting trip freight rates (monthly index) in the dry cargo market were also attempted successfully (Goulielmos-Psifia, 2008). There are also many occasions (Goulielmos-Psifia, 2008) when distinguished and capable maritime economists, such as Kavussanos, have measured and mentioned heavy departures from normality with excess kurtosis and excess skewness in freight rates.

Moreover, normal distribution was the premise on which the 'hypothesis of effective markets' was erected. This structure was developed to include such famous constructions as the 'Capital Asset Pricing Model' (CAPM) due to Sharpe (1964), Lintner (1965) and Mossin (1966), and the 'Modern Portfolio Theory' (MPT) developed in the pioneering work of Markowitz (1952). According to traditional financial models, investors have rational expectations and try to maximize returns and minimize risk (i.e. variance). In the meantime, the financial crises (notably Black Monday in 1987, Russia and other nations in 1998, Wall Street, 1998 and the 2007/8 crisis due to high risk housing bonds in USA, among others) all over the world, and the great losses over various funds amounting to billions of dollars, led scientists to reconsider the infallibility hypothesis of the random walk model.

Li & Parsons (1997) made statements in the maritime literature to the effect that the traditional linear ARMA models were ineffective: "It is very rare that individual or aggregate economic activities and their interactions are purely linear". Despite this criticism, these models are still widely used today. On the other hand, Li & Parsons were not completely successful in modeling the markets either. Their predictions gave mixed maximum deviations using ANN & ARMA. They wanted to

¹⁶ A non-stationary time series presents a trend or seasonality or a changing variability. In more technical terms all time series 'moments' must not change with time in case of stationarity. Nonlinear stationarity means (Small) a situation unchanged by the system's dynamics over time. Here we work with so called 'invariants'. For Small (p. 47 et seq.) the 'invariant' is a quantity describing the dynamical behaviour of a system with the special property that its value does not depend on the coordinate system or the value of a dynamic invariant obtained directly from the original system will be the same in a particular transformation such as a change from an original phase space to time-delay reconstruction, as we did in this paper.

¹⁷ Meaning finding the dimension of the system.

¹⁸ As in Siriopoulos & Leontitsis (2000, p. 5).

¹⁹ The authentic (original) phase space is not known and thus we must reconstruct it using only our time series.

²⁰ The ARIMA (0, 1, 0) model is also the discrete time analogue of the Brownian motion/random walk. The connection between the two was proved for Physics in 1905 by A. Einstein.

²¹ With the BDS-statistic (from the initials of Brock-Dechert-Scheinkman) we test the difference in the dispersion of the observations, in spaces for a dimension from 2 to n, compared with white noise (IID).

investigate whether Neural Networks²² (NN) can improve the predictability for maritime business in both the short *and the long* term and to provide a framework for practical application. They recognized, as we did, that improvement in forecasting accuracy is a difficult task, but critical for business success. They drew upon the literature on Neural Networks that appeared between 1989 and 1993 and especially after 1991. In fact, they followed the significant effort between 1986 and 1993 to develop *nonlinear* mathematical models, something which they admitted was extremely difficult. They used the monthly tanker freight rates for 1980/1995. An important part of their methodology is their claim that, at least in theory, the “feed forward NN” can approximate any complicated *nonlinear* function under certain assumptions. So, the advantage of their model is its ability to deal with *nonlinearity*, and this provided a considerable improvement on traditional methods in forecasting (time series models). The latter, for simplicity, used, or rather assumed, *linearity*. In terms of the forecasts that Li & Parsons (1997) produced, we have paid most attention to the points where their model failed accurately to predict and this is where differences between actual events and forecasts are at a maximum. The key points where these failures occurred were as follows: in predicting one month ahead NN had a 95 WS units deviation (ARMA 95-100, equivalent or worse), in predicting five months ahead the deviation was 102 (104-105 ARMA, worse); 12 months ahead 105 (ARMA 100, better) and 24 months 110 WS units (ARMA 110, the same).

Lyridis et al (2004) attempted to demonstrate the benefits of using artificial neural networks²³ (ANNs) in forecasting VLCC (very large crude oil carriers/ships) spot freight rates and analyzed data from 1979 to 2002 for the route Ras Tanura-Rotterdam for 1, 2, 3, 6, 9 and 12 months ahead. Forecasting was based on the fact that the past values of time series may influence future values, which, however, implies a *failure* of the validity of the market efficiency hypothesis. ANNs are argued to be more suitable for the analysis of non-stationary,

22 A computer-based simulation, considered as imitating/mimic the human nervous system and it can learn from experience.

23 ANNs were considered as an advanced pattern recognition technique with application in time series forecasting. See also [Zapranis, 2005].

non-linear time series (such as those found in the tanker market). The following eleven factors were found to be the most important: demand, active fleet, crude oil production price, surplus, time charter rates, new build, second hand and scrap prices, and oil stock building. We have again calculated the *maximum* differences between their forecasts and two month actual freight rates as follows: over a one month period 30 WS units; over 3 months 45 WS units; 6 months 55 WS units; 9 months 60 WS units and 12 months 42 WS units. Their forecasts are better than those of Li & Parsons (reviewed above).

Small (2005, p. 226) also reported that, when he used appropriate surrogate data and test statistics for financial data, he also found strong evidence that the standard financial heteroskedastic models of ARCH, GARCH, EGARCH & ARMA were wrong. They did not offer an adequate description of reality, and he concluded that the market is genuinely not efficient.

Derman (2004) argued that *geometrical Brownian movements* and their idealizations *do not represent an accurate description* of the financial variables. The most notable critique however, in terms of the volume of work produced, its duration and its consistency is that of Mandelbrot (2004). These were, of course, followed by many others (e.g. Goodwin 1990, Peters, 1994).

Engelen et al (2006) developed the work of the 1934 “Tinbergen school”, and provided a system dynamics model for endogenous ship-owners in the dry bulk sector. They distinguished between strategic and tactical choices of ship-owners and argued that ‘system dynamics’ seems to provide a complete and appropriate method for the detailed modeling of strategic and operational behavior in maritime business. Their model started from a business game in 2005 between Antwerp University and Delft Technical University presented in the 2005 conference of IAME (International Association of Maritime Economists). Engelen et al (2006) tested the system that underpins the different shipping markets. This is based on the work of Sterman²⁴ (2000) and the Vensim programming package. An important benefit that their tool provided is the possibility of a very detailed treatment of “time”, which had previously been

24 “Business dynamics: Systems thinking & modelling for a complex world”, NY, McGraw Hill, USA.

missing in analyses of shipping. They adopted a system dynamics model that made it possible to generate complex *non-linear* functions which were extremely difficult to develop in econometrics, as they noted. However, if a time series has a memory, the *geometric Brownian motion* they assumed cannot be readily applied, and renders their whole simulation work problematic (Derman, 2004). And indeed this memory can be shown to exist in our time series data, as shown below (Diagram 1.5).

Analysis I

As mentioned above, the first issue to be dealt with in any analysis is the matter of *stationarity* in a time series. This is a fundamental characteristic for a time series. In most cases the models operate on the assumption that the process that has created them *is stationary*.²⁵ Various methods can be used to transform a time series from non-stationarity to stationarity. One, suggested by Box & Jenkins in 1976, uses the first differences of the variable. This transformation can subtract linear trends from X_t , and even from non-linear polynomials can be transformed by using a lag operator, among other methods. In our case we use as a filter the first logarithmic differences, after the manner introduced by Peters (1994, p. 62), and in this way make our time series stationary. This job is done here either using software MATLAB 5.3 and/or by using the package NLTSA²⁶ V. 2.0 (2000) or both.

The *normality* test can also be performed with various methods. One is related with skewness (=0 if normal) and another with kurtosis (=3 if normal). If kurtosis (in the case of the time series described here this is equal to 10.063) is greater than 3, the distribution is *leptokurtic*. In our case skewness found to be equal to -0.051, that is it is less than zero. The normality test was

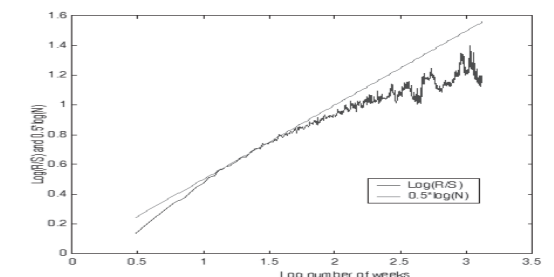
25 A linear system is stationary if all its moments (mean, standard deviation, kurtosis, skewness etc) remain unchanged with time. A non linear system has other requirements for stationarity as described here (Small, 2005).

26 This software runs under MS-DOS at the moment and its code is written in C/C++. It will accept some 16384 observations and its name is an acronym for Nonlinear Time Series Analysis. This program provides six filters to make time series stationary. NLTSA, non-linear time series analysis software, version 2.0 (upgraded) (2000).

performed using the Jarque-Bera 1980 test²⁷. The result (2608) was greater than 5.99, the value that would have indicated normality. Consequently, normality is rejected at the confidence level 0.01, where the critical value of JB value is 9.21. So, the assumption that our time series is *normally distributed* is rejected. Leptokurtosis is the condition of a probability density curve that has fatter tails and a higher peak at the mean.

One of our next jobs in this paper is to test our time series for *long term (infinite) memory*. Another way of describing this test is whether our observations are *independent* (and unbiased). We have chosen to use a technique called “Rescaled-Range Analysis” to achieve this – a non-parametric method developed by the famous hydrologist Hurst in 1951 and brought to application and prominence by Mandelbrot (1972) and later applied to finance by Greene & Fielitz (1977) and Peters (1994). This methodology enables us to estimate rare events using the so called ‘Hurst exponent’ H. Using H we can estimate our time series’ bias or trend and its speed. In Diagram 1.4, the straight line with slope 1/2 shows the expected result for an unbiased (random walk) time series. It can be seen that the irregular line indicating our observed results is always below that straight line, although it approaches the line tangentially for approximately 72 weeks (log=1.23 to 1.94, 16-88 weeks). The freight rate index has a speed *lower* than the unbiased value for the first 15 weeks or so (log 1.18) and diverges from the unbiased value again, reaching a value of 0.31 at the end of 1313 weeks (log=3.12).

Diagram 1.4: Speed of time series Random (red line) and biased (blue line-actual) of 1313 oil weekly freight rates, 1983-2008.



27 As follows: $JB = [N/6 \times (\text{skewness number}) + (N/24) \times (\text{kurtosis number} - 3)^2] = 2608.3034 > 5.99$ (χ^2) at a confidence level at 0.05 at 2 degrees of freedom, and for $N=1260$ using Chi square method.

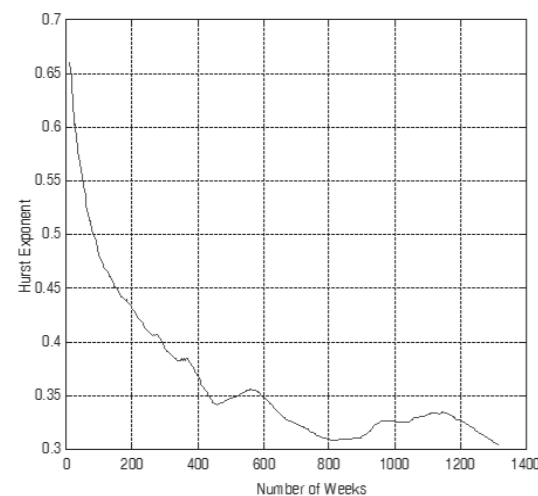
Source: calculated by MATLAB 5.3 using Rescaled Range Analysis

Hurst first defined the difference between the maximum and the minimum of a cumulative deviation of a distribution, i.e. $R(n) = \max[x(t,n)] - \min[x(t,n)]$ and divided it by the standard deviation of the sample s . Hurst proved that: $R(n)/s = (an)^H$ where $0 < H < 1$ is the Hurst exponent and 'a' is a constant. H can be estimated by regression as follows: $\log(R(n)/s) = \log a + H \log n$.

The bias is created by the investors in capital markets as they react in the current economic conditions pending the arrival of new information, and modifies the previous bias. Mandelbrot & Taqqu (1969) and Mandelbrot & Wallis (1979) have shown the strength of this criterion compared with traditional and classical methods of autocorrelation analysis or variance ratio, even when applied to non-Gaussian distributions with heavy kurtosis and heavy skewness, as in shipping. Moreover, we can detect short/medium/long term non-periodic cycles, something that is very important for the shipping industry, which in previous research has been considered to be a purely cyclical industry.

Calculating the Hurst exponent using first logarithmic differences as a filter both with MATLAB 5.3 and NLTSA V.2.0, we found a maximum $H=0.66$ for $n=11$ (weeks). The maximum exponent is that which characterizes the time series [Siriopoulos-Leontitsis, 2000].

Diagram 1.5: The Hurst exponent of tanker weekly freight rates time series versus 1983 (05/01)-2008 (27/02).



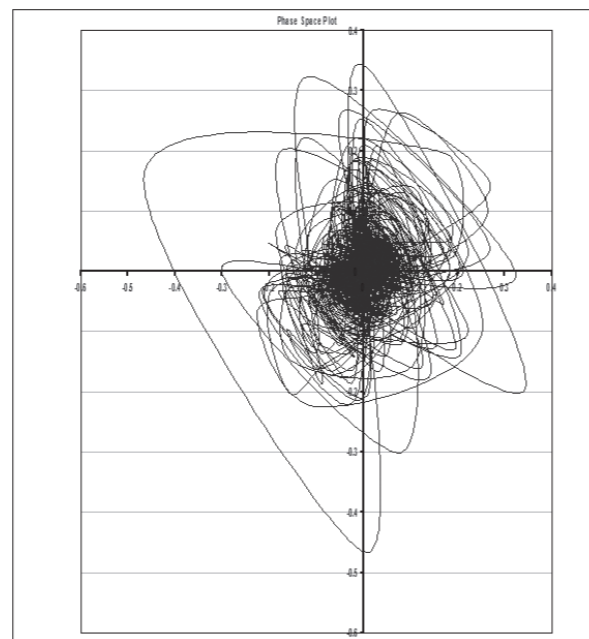
Source: 1313 week freight rates using MATLAB 5.3 program and first log differences as a filter.

The series thus shows a persistence, $H > 0.5$. Thus we characterize the time series as *persistent* (*trend-reinforcing*). This kind of time series in Rescaled Range Analysis gives a tendency of a series to follow trends. If the system has increased in the previous period, the chances are that it will continue to increase in the next period. Persistent time series have a long 'memory'; long-term correlation exists between current events and future events (Black noise). The tendency for persistent time series to have trend and cycles is also called the Joseph effect (a term due to Mandelbrot, borrowed from the Bible). The Hurst exponent is also the characteristic exponent for fractal distributions ($=1/a$ where $a=1.51$ here which is less than 2 which is what it would be for an unbiased series).

Analysis II

In this section we will investigate the relevant dynamical tools indicated in our work flow Diagram 1.3. These are (1) the *fractal dimension of the attractor*. The *attractor of the freight rates 1983-2008* is diagrammatically shown in Diagram 1.6.

Diagram 1.6: The attractor of weekly freight rates 1983-2008



Source: Calculated by Dr Psifia using MATLAB 5.3. This is a similar shape to that of the general index of the Athens stock exchange from minute to minute from 10.45 to 13.30 for the period of 01/06/1998 to 10/09/1998.

The **attractor** is a definer of the equilibrium level of the system. Alternatively, an attractor is a set of points in the phase space towards which the trajectories of values **tend** asymptotically over time, for a given set of initial conditions and in the long term. A chaotic attractor is dependent on initial conditions. Attractors (strange) are objects with 'fractal' properties. *Fractal* is a non integer value (never imagined by Euclid) that quantitatively describes how an object fills its space. The theory of fractals²⁸ evolved in parallel with Chaos Theory and the two sets of concepts are importantly linked. Fractals were brought to the forefront by Mandelbrot in the geography of Nature in 1974. Fractals are all the objects that are self-similar on different scales.

(2) The maximum *Lyapunov exponent*. A Lyapunov exponent is a number that describes the dynamics of trajectory evolution in phase space. Its value can be negative, zero or positive. A positive exponent indicates sensitive dependence on initial (starting) conditions. Alternatively it means how one series can diverge from another when starting conditions are differently estimated. Also a positive (>0) maximum Lyapunov exponent indicates the presence of a chaotic attractor. We will use the Lyapunov exponent to determine the predictable time horizon (West & Mackey, 1992).

In this paper, a local non-linear prediction model will be used, as proposed by Farmer & Sidorowich, 1987 and described in detail in Appendix I. This model is widely used and is successful in the analysis of dynamic time series, even when observations are relatively few. More importantly, this model will provide us with useful information concerning the reconstructed phase space's²⁹ *embedding dimension*, which is the total number of separate time series [(consisting of the original series and subgroups of them obtained by lagging³⁰ (delaying) these series used in a reconstructed phase space (see also Takens³¹ (1981))].

²⁸ A fractal is, by definition, a set for which the Hausdorff Besicovitch dimension strictly exceeds the topological dimension.

²⁹ The number of coordinates needed to locate a point in phase space where the trajectory of the system belongs.

³⁰ The time τ that is chosen is the one that leads the autocorrelation function to zero for the first time $rx(\tau) = 0$. If this is not the case, then: $rx(\tau) = 1/e$

³¹ Takens' theorem is ideally applicable to time series with infinite size and without noise.

In addition, and most importantly, this method combined with the Ordinary Least Squares Method and the Kernel Density Analysis method has offered us a way of describing the oil cargo freight market with rather low estimation errors ($E=0.60 < 1$ & 0.55 ; where $E=0$ indicates perfect forecasting; for more details please see below).

According to Farmer and Sidorowich (1987) (Appendix I), the modern theory of forecasting is based on the view that a time series is a realization of a random process, which can be caused by Chaos (in very simple deterministic systems with few irreducible degrees of freedom). Systems will be amenable to forecasting if the 'state space' collapses onto an attractor of only a few (less than 10) dimensions. (Our results for the oil cargo freight market give a value of slightly over 5 in this paper).

If the data are a single time series, as in this paper, the first step is to embed it in a state space.

Determining and Calculating the Embedding Dimension m .

We need to find out the embedding dimension m in the reconstructed phase space. According to Takens' theorem 1981 we must have $m \geq 2D+1$ for the reconstructed attractor to have trajectories that do not intersect³². However, Takens' theorem determines the sufficient, but not the necessary, condition (as we want m as small as possible). Thus, for the required best embedding dimension m' , according to Kennel et al. (1992), we must have $d \leq m' \leq 2D+1$. However neither D nor d (the topological dimension of original Manifold) are known.

1. To proceed, we will use the "method of false nearest neighbours" (FNN)³³ to approximate, which will give us the dimensions of the system using the relationship between false neighbours and intersections of the trajectories. Analytical presentation of this method is given in Appendix II.

³² Intersections exist when the system has two solutions at the same initial conditions, something prohibited by Takens' (1981) theorem.

³³ We find that in a dimension m if two points in the reconstructed attractor say x_i^m & x_j^m are too close, two conclusions are possible: (1) these are real neighbourhood points and are close due to the dynamics of the system or (2) these are false neighbourhood points that are close due to a trajectory cut.

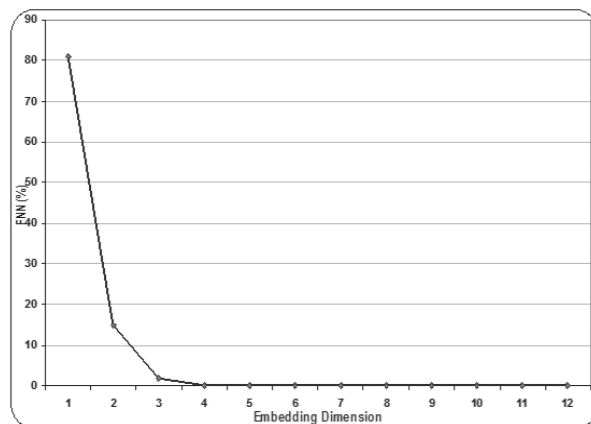
2. The method is based upon the relationship that exists between false neighbours and intersections of the trajectories. Following the above procedure and with the aid of specific software [NLTSA], we have analyzed our data (1313 weekly observations) of the freight market world-scale index, 1983-2008, and for $\tau=1$ (time delay³⁴). We then constructed Table 1.1 and Diagram 1.7:

Table 1.1: Freight tanker Market 1983-08 Embedding dimensions & Percentage of False Nearest Neighbors

EMBEDDING DIMENSION (m)	% (FNN)
1	81,00%
2	15,00%
3	2,00%
4-12	0,00%

Prepared by Dr. Psifia E. M., (2008), using [NLTSA].

Diagram 1.7: The Relationship between % of False Nearest Neighbours and Embedding Dimension when $\tau=1$. Freight tanker market, 1983-2008.



Source: Table 1.1.

Thus for an embedding dimension of 3, the % of false nearest neighbours is 2.0% (Table 1.1) and for 4 upwards the percentage falls to and stays at 0%. So, this means that we need more than 3, i.e. 4, equations. So the dimension here is $d=4$.

(a) Determining Attractor's Dimension.

Now, we have to calculate accurately the dimension (presumably fractal, non-integer, and thus chaotic) of

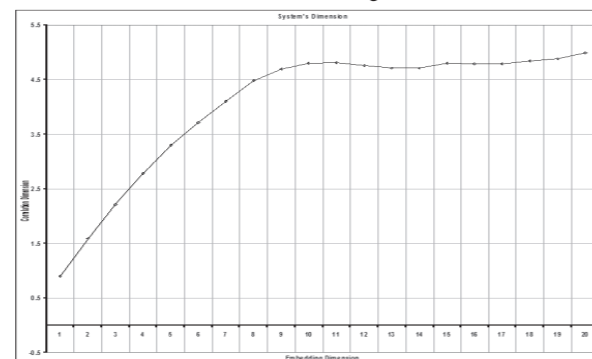
³⁴ The smallest value of τ that makes the variables of x_i uncorrelated is chosen.

the relevant attractor. We proceed now to embed our time series into successive dimensions to see whether there is some kind of stability in the form of the object that will be formed. *There is expected to be the attractor.* The method that is now used to calculate accurately the attractor's dimension (system's dimension) is the "Correlation Dimension³⁵ Method" (due to Grassberger & Procaccia (1983)) which is simple and widely used. Here we have first to find out the Correlation Integral³⁶ (Siriopoulos-Leontitsis, 2000, p. 111). This theory is further explained in Appendix III.

(1) Application of the Theory.

With the appropriate software [NLTSA 2.V.0, 2000] and our data from the weekly oil cargo freight rates world-scale index for 1313 weeks, between 1983 and 2008, and for time delay 1, we located a stabilisation of the correlation dimension slightly above 5, as shown in Table 1.2 and Diagram 1.8.

Diagram 1.8: The Relationship of Correlation Dimension & Embedding Dimension



Source: Table 1.2 & Psifia E. M., 2008.

Our freight rates attractor has a correlation dimension slightly over 5 which is a fractal

³⁵ A method that estimates the fractal dimension measures the probability that two points, chosen at random, will be within a certain distance of each other, and examines how this probability changes as the distance is increased. A dependent system will be held together by its correlations and will retain its dimension in whatever embedding dimension is placed, so long as the embedding dimension is greater than its fractal dimension.

³⁶ This gives the probability that 2 points are within a certain distance of one another.

Table 1.2: The Relationship of Correlation Dimension to Embedding Dimension

Embedding Dimension	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Correlation Dimension	0.9	1.59	2.21	2.78	3.3	3.71	4.1	4.48	4.69	4.8	4.81	4.76	4.71	4.71	4.8	4.79	4.79	4.84	4.88	4.99

Calculated by Psifia E. M., using NLTSA.

attractor and thus chaotic. Moreover, the system's correlation dimension will be taken as equal to the next integer i.e. 6. *This means that the weekly oil freight market 1983-2008 is a low dimensional (less than 10) system, which will allow us to make short term – though very important – predictions.*

(b) Determining Lyapunov's Exponents.

We have seen in the previous section that our attractor is chaotic. Chaotic systems show, as a rule, sensitivity to initial (starting) conditions (Appendix V), as they are systems expressing a power law. This is also known as the famous – and previously mentioned – 'butterfly effect'. This is also considered to be a cause for our inability to predict in the long run. But this inability is reduced with the help of the attractor, provided the points are near it, for if so then they are 'orbited' (attracted) by the attractor (Siriopoulos, 1998, p. 132). Further details are given in Appendix IV.

Now, let λ_1 be the (maximum/maximal) Lyapunov exponent (among many) indicating the average digression of points in the direction of the largest one in the phase space. This will be the Lyapunov exponent that will be the focus of our attention, and its sign will be of particular importance. If this is positive, it indicates a digression, at least in one dimension, of the nearest points of the attractor in the time evolution, and determines the chaotic attractor.

(1) The Estimation Method for λ_1

To estimate λ_1 , from the attractor formed by the totality of the reconstructed points in the phase space, the method of Kantz [1994] will be followed. This is considered to be a robust method; and it also addresses effectively possible problems that arise from the ill selection of the embedding and time delay coefficients. As Kantz [1994] argued, "The Lyapunov char-

acteristic exponents' (if positive) 'by definition are the most striking evidence for Chaos'. These characterizations constitute identification elements of chaos and they provide a deterministic solution. A chaotic system – globally constrained to a finite region in the 'state space' – is locally unstable everywhere. (This is also described as local randomness, global stability.)

The calculation of λ_1 will be carried out next. More detail is provided in Appendix V.

(2) Calculating the Largest Lyapunov Exponent

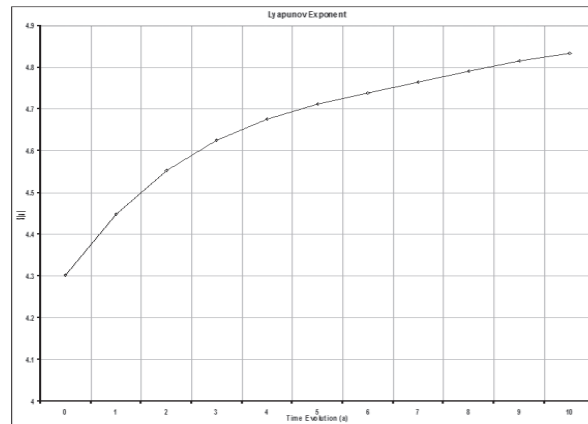
The method (Appendix V) is now applied [using NLTSA] to the 1313 weekly freight rates with a time delay of 1, embedding dimension $m=10$ (as $D>5+$, given also that $m \geq 2D+1$). λ_1 is now estimated for the first 5 values of S (a) (including zero) where these belong to an area where the error is very small [$R^2 = 94.3\%$], and equal to +0.080171 as shown in Table 1.3 and Diagram 1.9:

Table 1.3: Estimation of the Maximal Lyapunov Exponent

A	S(a)	Largest Lyapunov Exponent Estimation	Slope of the regression $S(a) = \lambda_1 * a + c$	R^2
0	4.302	–	0.080171	94.3%
1	4.448	0.14550		
2	4.553	0.10530		
3	4.625	0.07200		
4	4.676	0.05095		
5	4.712	0.03528		
6	4.739	0.02754		
7	4.765	0.02601		
8	4.791	0.02551		
9	4.815	0.02412		
10	4.834	0.01934		

Calculated by Psifia Elpiniki-Maria (2008)

Diagram 1.9: Lyapunov Exponent for Oil cargo world-scale Index, 1983-2008



Source: Table 1.3

From these results we can see that our time series has a *fractal dimension* and a *positive* Lyapunov exponent, which means that it is created by a *nonlinear deterministic dynamic system*. We come now to attempt prediction³⁷ and forecasting of the freight market.

Forecasting/predicting Oil Weekly Freight Rates with a Non Linear Model

(a) Introduction

The invariant characteristics of the dynamic system have been preserved in the reconstructed phase space, where our time series was a part. Now the *suitable* (Lillekjendlie et al, 1995) prediction model remains to be specified. For our chaotic time series, we pay the price of not having long term predictability, unless we know the initial (starting conditions) conditions, *which we do not*. The maximal Lyapunov exponent on the other hand specifies our prediction limit to be 12 weeks.

(b) The Model

As mentioned, the Farmer & Sidorowich [1987] method (Appendix I) will be applied here. First, we will calculate the estimation error.

(c) The Estimation Error

The predictive ability of a model is tested by estimating [Zapranis, 2005] the error (E) using equation E below.

The outcome from the equation is also called normalized error. This equation has the task of evaluating the accuracy of the predictions, computing the root-mean-square error denoted by: $\sigma_{\Delta}(T) = \sqrt{[X_{pred}(t, T) - X(t+T)]^2}$, where T is the prediction time. This can be normalized by the deviation of the root mean square of the data: $\sigma_x = [(X - \langle X \rangle)^2]^{1/2}$, forming the normalized error $E = \sigma_{\Delta}(T) / \sigma_x$. If E=0 the predictions are perfect and if E=1 the performance is no better than a constant predictor: $X_{pred}(t, T) = \langle X \rangle$.

$E = \frac{\sqrt{\sum(x_{predicted} - x)^2}}{\sqrt{\sum(\bar{x} - x)^2}}$. Where $x_{predicted}$ is the predicted value of the corresponding value x of the time series and \bar{x} is the mean value of all observations up to value x of time series. The sums change as we use all observations up to n to predict n+1, then n+1 to predict n+2 and so on. The meaning of the above equation is that if the time series is **random** the best prediction is the mean (then E=1).

(d) Prediction (inside the sample)

The last 12 observations of our time series can now be predicted within the sample (although known). We used first the 1313 minus 12 observations to predict the 1301 th and so on. We have also found the suitable coefficients of the model starting from number 1 out of 12 and trying to minimize the E (error). These coefficients will then be used for prediction step by step. The predictability limit is given by $\lambda_1 \sim t^{-1}$, where t is the mean time in the future by which the knowledge of a present situation can be used to predict [Siriopoulos-Leontitsis, 2000] and for our case:

$$(\lambda_1)^{-1} = \frac{1}{0.080171} \cong 12.47 \rightarrow (12weeks)$$

The number of the nearest neighbours' k is specified at number 9 and 20.

The greatest deviations took place in October, November and December 2003, when compared with the real freight rates (not shown here).

³⁷ We have adopted here the terminology of Siriopoulos-Lentitsis, 2000, p. 183, where by predictions we mean inside the sample and by forecasting we mean outside the sample.

Table 1.4: The Last 12 Steps Using one Step Predictions of Oil world-scale Index: (a) for 15th November, 2006-28th February, 2007, (m=5, τ=1, k=9 & E=0.52) and (b) for 12/12/07 to 27/02/08, using OLS, m=8, t=1 and k=20 (E=0.6).

WEEK	REAL VALUES	PREDICTED VALUES (ROUNDED)		% DIFFERENCE (ROUNDED)	PREDICTED VALUES	
		ORDINARY LEAST SQUARES			KERNEL DENSITY ESTIMATION METHOD	% DIFFERENCE
15 th Nov. 06	110	172		56	-	-
22 nd Nov. 06	100	134		34	-	-
29 th Nov. 06	100	107		7	-	-
6 th Dec. 06	120	120		0	-	-
13 th Dec. 06	220	134		-39	-	-
20 th Dec. 06	280	308		10	-	-
27 th Dec. 06	280	293		4.6	-	-
3 rd Jan. 07	260	307		18	-	-
10 th Jan. 07	170	223		31	-	-
17 th Jan. 07	200	177		-12	-	-
24 th Jan. 07	240	238		-0.8	-	-
31 st Jan. 07	120	181		51	-	-
7 th Feb. 07	120	146		22	-	-
14 th Feb. 07	120	131		9	-	-
21 st Feb. 07	165	115		-30	-	-
28 th Feb. 07	260	163		-37	-	-
12/12/07	215	175		-19	152	-29
19/12/07	220	237		8	213	-3
26/12/07	200	200		0	213	6.5
02/01/08	160	191		19	185.5	16
09/01/08	120	145		21	148	23
16/01/08	200	127		-36.5	136	-32
23/01/08	160	188.5		18	184	15
30/01/08	130	84		-35	143	10
06/02/08	117.5	157		34	143.5	22
13/02/08	120	129		7.5	134	12
20/02/08	130	151		16	125	-4
27/02/08	125	112.5		-10	134	7

(e) Forecasting outside the sample

Using the OLS (Ordinary least squares) with $m=8$ (embedding dimension), $t=1$ (time delay) and $k=20$ (number of nearest neighbours) and KDE as shown, we derived the following forecast values:

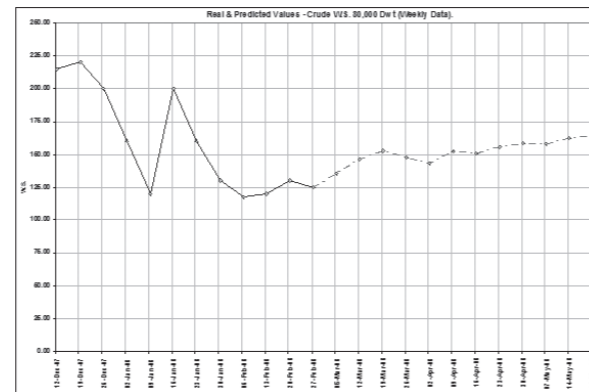
Table 1.5: Forecast outside the sample with OLS & KDE

OLS & KDE	
Date	Real (normal) & Forecast Values (bold italics)
12-Dec-07	215
19-Dec-07	220
26-Dec-07	200
2-Jan-08	160
9-Jan-08	120
16-Jan-08	200
23-Jan-08	160
30-Jan-08	130
6-Feb-08	117.5
13-Feb-08	120
20-Feb-08	130
27-Feb-08	125
5-Mar-08	135.5
12-Mar-08	146
19-Mar-08	153 KDE (*)
26-Mar-08	147.5 KDE (*)
2-Apr-08	143
9-Apr-08	152
16-Apr-08	151
23-Apr-08	155.5
30-Apr-08	158
7-May-08	158
14-May-08	162
21-May-08	164.5

Source: Psifia, 2008. (*) $m=5, t=1, k=6$

Diagram 1.10 presents our actual and forecast values of the index between 12th December 2007 and 21st May 2008.

Diagram 1.10: Forecasting Weekly freight rates of world-scale index based on 1313 observations for 12th December 2007 to 21st May 2008.



Dotted line: forecasts between 5th March 2008 to 21st May 2008.

This represents the conclusion of our work.

Conclusions

This paper begun as a departure from both linear and nonlinear stochastic models which have followed the long-celebrated Random Walk models (AR etc.). Our weekly tanker freight rates 1983-2008 time series has shown serious signs of anomalies, including excess kurtosis (10.063) and excess skewness (-0.051), and the Jarque-Bera test rejected normality at the 0.01 and 0.05 confidence levels ($2608.3 > 5.99$ and > 9.21). We have first transformed our time series into a stationary series, as necessary for the methods employed, using as a filter the first logarithmic differences of the observations, omitting one observation. The speed of our time series consisting of 1313 weekly observations was found to be different from that of a random walk (at square root of time) and using the Rescaled Range Analysis method we found the Hurst exponent to be equal to $0.66 > 0.50$. Our time series thus showed persistence and long term memory and is not random. This method determines long memory effects and fractional Brownian motion. Although this method tells us that there is a fractional power (meaning interdependent observations) here, because our time series travel over time i.e. $0.66 \sim 7/10$, we needed to employ the methods and procedures found in dynamic systems.

The tools available in dynamic systems analysis consist of the phase space and its reconstruction. The authentic phase space is unknown and we only have evi-

dence for our time series and this is in discrete time. An important concept in the phase space is the attractor (a set of points) which with the help of MATLAB 5.3 we have presented graphically in Diagram 1.6. We wanted to see whether this was chaotic in its dimension, as it in fact turned out to be, with dimension approximately equal to 5. To determine the attractor's dimension we used the Grassberger & Procaccia (1983) procedure, which requires the correlation (~ 5 , and for the system 6) and embedding (~ 4) dimensions. Chaotic time series are also sensitive to initial conditions, something that is indicated by the Lyapunov exponent. This exponent is also needed to tell us how far into the future the system can be forecast. The exponent was found to be equal to $+0.08$, meaning a horizon for prediction equal to $12 \frac{1}{2}$ weeks.

Using various methods and exponents we have shown the data to form a low dimensional chaotic time series, and it was this that we wanted to forecast. Using

the Farmer & Sidorowich (1987) method we calculated a forecast outside the sample, which is presented in Table 1.5. The forecast methods we have used are nonlinear and are called local. First we used the Ordinary Least Squares method which required the embedding dimension, the time delay, the nearest neighbours and the number of steps to be forecast. Also, we used the Kernel Density estimation method, which required the embedding dimension, the time delay, the nearest neighbours and the steps for forecast. The methods were chosen from among six possible methods by the estimation error, which were calculated to be equal to $0.6 < 1$ and $0.5 < 1$. How much faith do we have in our forecasts? This was tested by our predictions inside the sample. The table below summarises our success:

The KDE seems to provide better forecasts. Only comparisons with actual events will show who is right and who is wrong.

Difference classes from actual values %	OLS	%	Cum. %	KDE	%	Cum. %
0-5	In 1 week	8	8	In 2 weeks	17	17
5.1-10	3 w.	25	33	3 w.	25	42
10.1-15	—	—	33	2 w.	17	59
15.1-20	4 w.	33	66	1 w.	8	67
20.1-25	1 w.	8	74	2 w.	17	84
25.1-30	—	—	74	1 w.	8	92
30.1-35	2 w.	17	91	1 w.	8	100
35.1-40	1 w.	8	99	—	—	
Total	12	100		12	100	

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Appendix I: Farmer & Sidorowich (1987) theory

The above authors stated that chaos is an alternative cause of randomness that can occur even in very simple deterministic systems (p.845). Their ideas came from, or were inspired by, efforts to beat the game of roulette in collaboration with Packard N. (p.845). The method runs as follows: Assume that have a single time series. Then, according to Packard et al [1980], we have to embed it in a state space as established mathematically by Takens [1981]. Then we create a state vector $X(t)$, with coordinates $X_1(t)=X(t)$, $X_2(t)=X(t-\tau)$, ..., $X_d(t)=X(t-(d-1)\tau)$, where τ is the *time delay* and d is the *embedding dimension*. Given an attractor of dimension D , then $d \geq D$ is a minimal requirement.

Next, we assume a functional relationship between the current state $X(t)$ and future state $X(t+T)$ as follows: $X(t+T)=f_T(X(t))$. At this point we need a *predictor* F_T to approximate f_T , and *for chaos this is necessarily nonlinear*.

For this the most effective approach is the "local approximation", using only nearby states to make predictions, and a superior approach (p. 846) is the *first order (or linear) approximation* taking k as the number of nearest neighbors, where $k > d$, and fit (by least squares by singular-value decomposition and $k > d+1$) a linear polynomial to the pairs $(X(t'), X(t'+T))$.

This method tries to predict next observation on the basis of the new position of the nearest neighbors of the last known value of the observation of the time series involved. The prediction for more than one, say p , time steps can be performed either directly or iteratively. In direct prediction we predict having registered the position of the nearest neighbors after p steps in the future. In iterative prediction we predict the next position first, then find out the nearest neighbors of the new position and repeat this process $p-1$ times. The latter was the method used in this paper.

In simpler language the above theory takes into account not only the movement of the closest neighbor, but also the movement of the whole neighborhood of the point we want to predict. The simplest way to predict our time series can be thought of in the following way: from the last point we will find the nearest neighbor and this will be a new value and our prediction. The method prescribes the following steps: (1) for our last point we chose the k nearest neighbors: X_j , $j=1(1)k$.

(2) we construct a linear system with k equations with m unknowns. (3) We solve the linear system $A\mathbf{c}=\mathbf{b}$. The predicted value is:

$$X_{N+1}(\text{pred.}) = \bar{b} + \sum_{i=1}^m c_i (X_i - \bar{X}_i) \text{ where } \mathbf{b} \text{ is the results vector.}$$

Appendix II: The method of Nearest False Neighbors/ FNN

First we test with $m=1$ and then:

1. We increase the embedding dimension by 1, and thus in the vector x_i^m we add the coefficient $x_{i-m\tau}$ to have x_i^{m+1} , and then examine the distance of x_i^{m+1} and x_j^{m+1} . (Exponents on the variables indicate the dimension).
2. If the distance increases substantially – according to a limit given by the ratio of the distances m and $m+1$ – then points x_i^m & x_j^m are false neighbors in the space R^m (reconstructed) and thus m is not adequately large.
3. For each point x_i^m we find its nearest point x_j^m and we test if this is a false neighbor or not.
4. If we find a substantial percentage of false neighbor points, we increase m by 1.

We continue the above process up to dimension m' , for which adding one more coefficient gives no more false neighbourhood points or gives so many that their percentage is equal to 1%.

Appendix III: The correlation integral

This gives us the correlation dimension using this formula:

$$C(r_k) = \frac{\sum_{i=1}^T \sum_{\substack{j=1 \\ i \neq j}}^T H(r_k - \|x_i - x_j\|)}{T(T-1)}$$

where: $r_k = k \cdot (\max - \min) \cdot 0,005$ and $k = 1(1)20$,

$$\|x_i - x_j\| = \sqrt{\sum_{i=1}^m (x_{i+(m-1)\tau} - x_{j+(m-1)\tau})^2}$$

and $H(x)=1$ if $x \geq 0$ or $H(x)=0$ (i.e. the Heaviside step function). This formula is also used for rapidity in calculations by multiplying the nominator by 2, and inserting $i=1 \dots T-1$; also $j=i+1$.

Also: $T = N - (m-1)\tau$, which is the number of points in the m dimensional space.

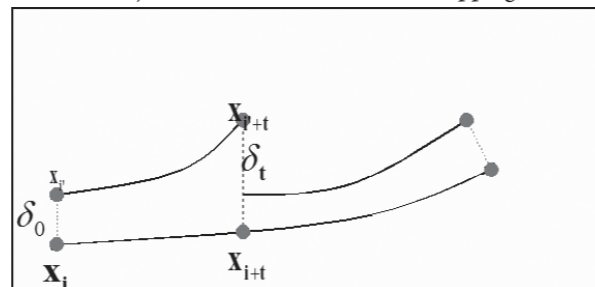
Given that an attractor may be constructed by a set of infinite points x_i , where x_i are the vectors $x_i = x_i, x_{i-\tau}, \dots, x_{i-(m-1)\tau}$, then the relation $P(|x_i - x_j| < r)$ expresses the probability that the distance of two points of the attractor will be closer than the distance r . If μ_i is the number of the points that are found within a sphere with radius r and center x_i , then the average value in relation to all $x_i < \mu_i > x$ approximates the above mentioned probability denoted by $C(r)$.

Thus we start with a small radius r , while a larger one, r' , will give $C(r')$. The correlation dimension is found by the slope (expected to become stable at v in the scaling region of r) of the regression line: $\log C(r), \log C(r')$... versus $\log(r), \log(r')$... The above process is repeated for successive values of the embedding dimension (usually up to $m=12$). Finally, the attractor's dimension is estimated when the integral dimension stabilises for increasing m 's (Kugiumtzis D., undated, p. 42). In fact $D^m = \lim$ when $\epsilon \rightarrow 0$.

Appendix IV: Sensitivity to starting conditions

The sensitivity to initial conditions makes system trajectories move apart rapidly after a time t , even when they start together, as mentioned. Let us have two points nearby x_i & x_i being on the chaotic attractor, belonging to two different trajectories of a distance $\delta_0 = \|x_i - x_i\|$ (Diagram AIV). Then after a time t we can see in the phase space that the two points are no more nearby one to the other, but one moved away from the other in an exponential way: $\delta_t \cong \delta_0 e^{\lambda t}$ [1.1] when $t \rightarrow \infty, \delta t = \|x_{i+t} - x_{i+t}\|$.

Diagram AIV: Exponential Digrission of Neighbour Trajectories in one Dimensional mapping



Source: Kugiumtzis D, (undated), p. 17. <http://users.auth.gr/~dkugiu/>

Two trajectories cannot of course digress for ever, and as time increases, every attractor is bound in the area of the space phase. Thus equation 1.2 is valid for time t and if δ_t remains small. The digression thus will be measured as $\delta_0 \rightarrow 0$.

Appendix V: The Lyapunov exponent

1. For every point x_i we form the neighborhood $U_{i,r}$ of radius r . This contains the points x_j ($j \in U_{i,r}$). We define r to be $(\max - \min) * 5\%$ so that to find at least m points in the neighbourhood, then this is increased by $(\max - \min) * 5\%$ (equal to initial quantity) (Kantz, 1994).

2. The distance of x_i from x_j after a certain time evolution a we define it to be:

$$dist(x_i, x_j, a) = |x_{i+(m-1)\tau+a} - x_{j+(m-1)\tau+a}| \quad [1.1]$$

3. The average of the above distances is the largest local exponent Lyapunov for point x_i . The average of all local exponents is the total Lyapunov exponent which is calculated by:

$$S(a) = \frac{1}{T-a} \sum_{i=1}^{T-a} \log_2 \left(\frac{1}{|U_{i,r}|} \sum_{j \in U_{i,r}} dist(x_i, x_j, a) \right) \quad [1.2]$$

where usually $a = 0(1)10$ and $T = N - (m-1)\tau$.

4. The maximal Lyapunov exponent is given by the following equation: $\lambda_1(a) = S(a+1) - S(a)$ [1.3], where the regression line slope as mentioned is given by: $S(a) = \lambda_1 a + c$ [1.4], where λ_1 is the slope and c is a constant, the value of which is immaterial in an area where the error is quite small.

Measurement of a CRM System Success:

The case of an incoming call center delocalized in Tunisia

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Many researches in the CRM domain were done within relational marketing orientation. Nevertheless, such researches didn't deal with company's global performance. Our study is realized within the operational competitiveness context which needs to considerate technical aspects of the Information Systems (IS), essentially through call centers. CRM systems success measurement is in fact a complex problematic issue, which interested companies involved further call centers investment. This exercise is so important for Tunisian companies that their customer interfaces are today mainly important to enhance profitability. Analyzed within the framework of a company integrating these new solutions via an incoming call center, empirical measurement concludes that system quality is the main determinant of the success of customer-oriented strategy. Service quality and information quality are respectively at a second and third order of importance. Finally, user and customer satisfactions are of an equal importance for their intermediate effect.

Keywords: CRM system success, operational CRM system, incoming Call Center, profitability
JEL Classification: M15

Introduction

According to Bae *and al.* (2005), reconsideration of customer relationship thanks to CRM systems can bring added value for both parties. Thereby, several companies whether multinational, or Small and Medium-Sized Companies (SMC) all over the world, have invested in CRM systems used through call centers.

However, experiences feedback haven't proven success of their integration to leverage their competitiveness (Cohen, 2002; Brewton, 2005).

This study aims to find out if CRM strategies, particularly actions undertaken within the framework of incoming call centers, can increase the profitability of Tunisian Companies. Therefore, through the literature, we intended to identify components of an operational

CRM system likely to influence company profitability. According to users' perception, success conditions for the integration of CRM technologies in this particular context, will be established.

1. Conceptual and theoretical dimensions

Companies have, firstly, made efforts to optimize their "back office"; then they recognized the importance of customer interface. The customers behaviour become conditioned by Information Technologies (IT) and a new culture focused on expected services more than a good product with a competitive price. Based on CRM applications, the "front office" appeared in order to allow companies to manage better their customers relationships.

1.1 Operational CRM

According to Renard (2000), CRM differs in a large way from a traditional marketing approach. The purpose is no more only to upsell more, but to win customer loyalty; to work on customer life cycle: to adopt a medium-term instead of a short-term strategy; customers more profitable; sell services and products together and offer various channels of distribution, but within one customer global vision. Such is the renewal experimentation of CRM paradigm which moves from a transactional to a relational practice and from a strategy of conquest to a strategy of consumer loyalty.

Marketing Information System (MIS) function is today enlarged with the integration of CRM solutions. This strategy allows a company to satisfy and to make loyal customers as well as to make more profit.

Combined, those technologies and methods support the functions of the company managing direct relationship with customers: sales, marketing and customer support (ADERA *and al.*, 2005). They facilitate data processing through better organization of information in data bases, better customer service management within the framework of call centers, etc. (Richard, 2001). We distinguish three CRM devices: Analytical CRM, Collaborative CRM and Operational CRM. The latter affects the transactional level managed by the front office. It governs and automates business processes integrated through its various contact points (sales points, call centers, etc.) (Lemmens, 2003).

According to Pronier (2000), call centers, contact centers and Customer Support Services (CSS) are

structures which integrate the most operational CRM technologies. Cohen (2002) and Chin *et al.*, (2002) note that it is the good use of contact centers that leads to the success of the integration of a CRM system. However, a question should be answered here, do we here talk about contact center or rather about call center? Below, a distinction is presented.

1.2 Call centers features

The literature dealing with operational CRM made several designations for customer relationship centers. All contribute to a closer significance, however different. The mostly used denominations are "call center" and "contact center" (IT Call, 2000; Cusack, 2002; CCIP, 2003; Todo modo conseil, 2004). Some definitions note a difference in their meanings, others confound them. In addition, most authors point out that the contact center is the extension of the call center by adding to the telephone a multitude of new communication devices based mostly on the Internet. The contact center seems to be the new version or the modernized profile of the call center (IT Call, 2000).

According to CCIP (2003), tasks carried out within a call center could be classified on a two-axis plan: The first one relates to customer life cycle (beforesale, sale, aftersale and loyalty development) and the second concerns the nature of calls made (incoming or outgoing calls). Here, the choice was for incoming calls in CSS which consists mainly on customer satisfaction management.

This choice is justified by the importance that call centers took today in order to manage CSS especially for services companies.

Many companies integrate CRM solutions through such centers without being able to measure their return on investment. Measurement of CRM system success is considered as one of the methods, which permits to quantify this indicator. Studied within the framework of a reception call center, this measure takes into account at a same time the reigning culture, logistics employed, human resources involved, processes adopted and the technologies integrated.

2. CRM system success measurement

In a call center, CRM system permits to enhance the contact value through their interaction with customer by telephone, to compare and to coordinate all sorts of

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information relating to him (IMFT, 2003). It assists the staff to improve the performance of their tasks in order to make them more profitable (Bharati, 2003). In the literature, there are many conceptual models of IS success measurement; however, none of them dealt with this specific context.

2.1 Subjacent models for IS success

In order to build an adapted model to measure CRM system success, within in an incoming call center context, three references were selected.

First, the DeLone and McLean's model (1992). It was designed to measure IS success according to six variables simultaneously, contrarily to previous studies which measured such success by a maximum of two variables. It advances two independent variables, system quality and information quality that explain the impact of IS on the organization. They have first an impact on two mediating dimensions, the system use and the user satisfaction. Then, those latters are interdependent between them and have impact on users. This impact ends up for an organizational impact (DeLone and McLean, 1992).

The DeLone and McLean's model (2002) is an update of the DeLone and McLean's model (1992) presented above. It consider "service quality" as a main variable after having been integrated to the "system quality". Further importance given to services as much as products justify this choice.

In addition, DeLone and McLean (2002) supported Seddon's proposal (1997) to keep a unique dependent variable, "Net benefits", supposing that any individual impact would inevitably have an organizational impact.

Roh, Ahn and Han's model (2005) is about the measure of CRM system success in insurance companies which is linked therefrom and more closely with the objective of our research.

The literature review allowed to adapt DeLone and McLean's model (1992) to the specific context of CRM systems. This point of view was founded on the supposition that identification of customers' needs and their satisfaction emerge as two essential conditions for the improvement of customer-enterprise relationship and firm's profitability (Roh *et al.*, 2005).

This model integrates three global dimensions: CRM initiatives, intrinsic CRM success and extrinsic CRM

success, and six respective variables: process alignment, customer information quality, system support, system efficiency, customer satisfaction and company profitability.

From those three presentations, was discussed the choice of variables retained, research hypothesis developed and thereafter was designed the conceptual model.

2.2 Conceptual model of research

Three global dimensions, seven identification variables and thirty one measure items were chosen to form the conceptual model content. Items finally selected were the result of a combination of a theoretical step through a literature review and the field validation of some operational gathered items.

2.2.1 CRM Initiatives (Initiativ)

Roh *and al.* (2005) defined CRM initiatives as the set of determinants allowing to success integration and deployment of the CRM system in the company. In the particular case of call centers, this theory can integrate three components: system quality, information quality and service quality.

According to Roh *and al.* (2005), CRM initiatives have direct impact on intrinsic success of the adoption of CRM technologies. By intrinsic success, they refer to internal success within the company, more precisely success related to the improvement of internal and external processes of customer relationship management. A high level of the quality of these attributes means that the company is applying the necessary mechanisms which enable her to manage customer relationship properly. Therefore, it succeeds the integration of its CRM system (Roh *and al.*, 2005). Then, a first hypothesis H1 supposing this bond will be tested:

H1: CRM Initiatives have direct impact on the intrinsic success of CRM system.

From this first principal hypothesis arise nine sub-hypotheses permitting to check the nature of the interdependence between the three variables defining CRM initiatives and those relating to the measurement of its intrinsic success (system effectiveness, user satisfaction and customer satisfaction) according the Roh *et al.*, (2005).

2.2.1.1 System quality (Sysqual)

According to Bharati (2003), system quality is a reflection of hardware and software quality. It represents a determinant of its global performance and can be measured through the individual perceptions of its users. DeLone and McLean (1992) established several measurements for this variable. These are: system response time, availability of the system, the ease of use and reliability. Here, the variable considers parameters related to technical and process management aspects. It is measured by following items: speed of access to the system, ease of access, usefulness and ease of use.

DeLone and McLean (1992 and 2002) suppose that system quality should have an impact on user satisfaction. Roh *and al.* (2005) note that it has an impact on effectiveness and customer satisfaction. Below are three hypotheses related to this variable which have been tested:

H1a: System quality has direct impact on user satisfaction.

H1b: System quality has direct impact on effectiveness.

H1c: System quality has direct impact on customer satisfaction.

The choice of measurement items used is justified by the operational character of the system to be studied.

2.2.1.2 Information quality (Infqual)

There are two types of information that a company can hold. The information that a company holds about its customers and the information that it provides to customers in response to their requests. DeLone and McLean (1992), Bharati (2003) and Roh *and al.* (2005) define information quality as the value produced by the system as perceived by its users. The real value of customer information lies in the insight that it can offer and in the customer-oriented action that it can trigger. Literature maintains that good information quality has an impact on the improvement of CRM processes and on the intrinsic success of the CRM system. Three sub-hypotheses are therefore tested:

H1d: Information quality has direct impact on user satisfaction.

H1e: Information quality has direct impact on effectiveness.

H1f: Information quality has direct impact on customer satisfaction.

Measurement items which permit to test the significance of this variable are associated with the integrity of information, its reliability and its availability. These items are as follows: completeness of customer information, completeness of the technical information offered, customer information accuracy, response accuracy, customer information provided just in time and technical information provided just in time (DeLone and McLean, 1992, 2002) and (Roh *and al.*, 2005).

2.2.1.3 Service quality (Serqual)

Service quality relates to the quality of services offered to customers. Where these services are embodied in a reception call center, it consists in particular in the interaction between the operator and customers measured by the quality of call reception and quality of processing customers requests. Parameters associated with attentiveness to customers, response quality and the assurance offered to them, have been established. Hence the verification of the following three sub-hypotheses:

H1g: Service quality has direct impact on user satisfaction.

H1h: Service quality has direct impact on effectiveness.

H1i: Service quality has direct impact on customer satisfaction.

2.2.2 Intrinsic CRM system success (IntrSucc)

Influenced by CRM initiatives, each internal impact of customer process management reproduce an external impact. By its three components, intrinsic success should involve an extrinsic success represented here by the improvement of company profitability Roh *and al.* (2005). A second principal hypothesis H2 is therefore tested:

H2: Intrinsic success has a direct impact on extrinsic success.

It presents the second level of the indirect impact of CRM initiatives on the improvement of profitability and results in three sub-hypotheses according to each one of the three variables defining intrinsic success.

2.2.2.1 User satisfaction (Usatisf)

It is the measure which is mainly used the most in studies which are related to companies satisfaction of the IS they are using. It can be defined by the level the users believe that IS is valid for them. To check the validity of the link between user satisfaction and extrinsic CRM success, the following sub-hypothesis is tested:

H2a: User satisfaction has direct impact on company profitability.

This variable is measured through users' appreciation of the following items: User satisfaction with interface, difference between the information needed and the information received, user satisfaction with functionalities and his overall satisfaction (DeLone and McLean, 1992, 2002).

2.2.2.2 Effectiveness (Effectiveness)

IS success is frequently defined in terms of the achievement of predefined objectives which include effectiveness parameters such as time, cost, and achievements (Roh and al., 2005). Effectiveness is an important and useful measurement of performance, closely related to but different from productivity and productivity difference. IS technical effectiveness has been less studied by researchers in this field (Roh and al., 2005).

In addition, in this study, effectiveness differs from that used in traditional IS success measurement, since it involves understanding the working procedure of CRM process by integrating system use. It is measured by: Making CRM easier, saving CRM cost, alleviating CRM load and saving CRM time (Roh and al., 2005). H2a is therefore tested:

H2b: System effectiveness has direct impact on company profitability.

2.2.2.3 Customer satisfaction (Cusatisf)

Customer satisfaction arises from their perceptions, their evaluations and their psychological

reactions during their experiences with product and/or service consumption. Negash and al., (2003) and Roh and al., (2005)'s showed that if the customer is satisfied, he is in close relation with the company, unless customer go with competitors. To succeed the CRM system integration, company needs to make sure that customers are satisfied. Sub-hypothesis H2c is then tested:

H2c: Customer satisfaction has direct impact on CRM extrinsic success.

Measurement items employed for this variable concern: Decrease of customer complaints, hold delay, call cost, request treatment, customer satisfaction regarding call center and customer satisfaction regarding the firm.

Finally, we should note that literature has showed that effectiveness is likely to have an impact on customer satisfaction (Roh and al., 2005). The following hypothesis is tested:

H4: Effectiveness has direct impact on customer satisfaction.

2.2.3 Extrinsic CRM success: Company profitability (IntrSucc, ImProf)

The need to measure the impact on company profitability is justified by the increasing importance of expenditure on investments in CRM technologies, in equipment and in the development of company services (Roh and al., 2005). The impact on company profitability reflects here the obvious results of the use of the system, which integrates the economic and strategic aspects of process management. It is measured by: Organizational effectiveness, increase of economic profitability, increase of upselling and increase of new customers.

According to DeLone and McLean (1992 and 2002) and (Roh and al., 2005), CRM initiatives have direct impact on extrinsic CRM system success. Therefore, checking hypothesis H3 becomes necessary:

H3: CRM initiatives have direct and indirect impact on extrinsic CRM system success.

The second part of the hypothesis is presented by combining two hypotheses previously defined (H1 and H2). It is a question of systematic deduction from H1 and H2 approved by Roh and al. (2005).

Variables retained and hypothesis developed serve to draw the model below.

The combination of process and causal model approaches made possible to have a descriptive and explanatory model. This serves to conduct a better analysis of interdependences between variables,

helps to test the validity of the model and offers possibility to conclude about its predictive capacity. Within this framework and reasoning on above mentioned models, the following model was developed (Figure 1).

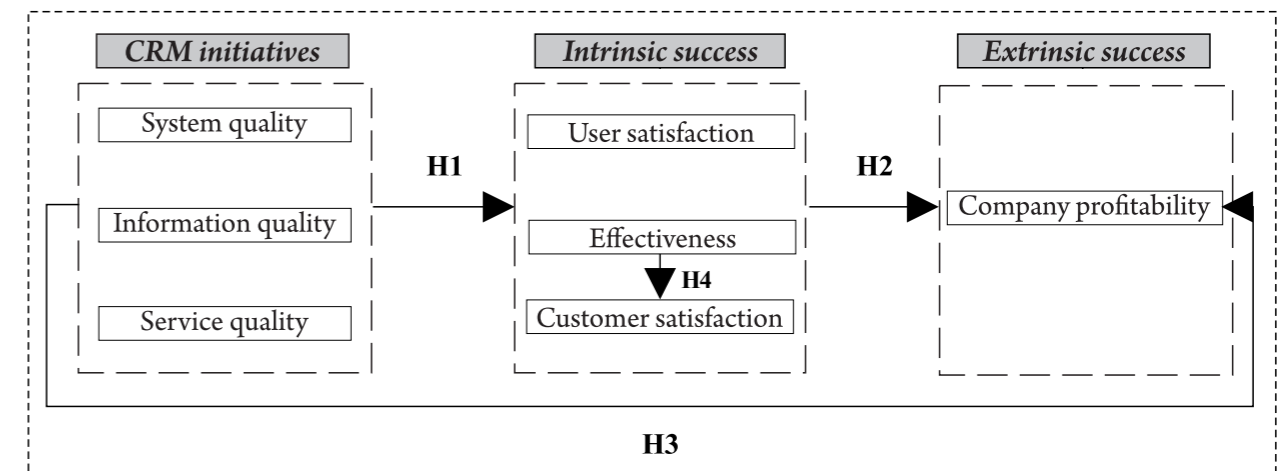


Figure 1: Conceptual model for measuring the success of a call center CRM system

The conceptual model conceived integrates three global dimensions: CRM initiatives, intrinsic CRM success and extrinsic CRM success. That seems to be equal to Roh and al.'s Model (2005), but there is a difference in their compositions.

In order to test hypotheses and the validity of the model, the empirical study carried out is detailed below.

3. Empirical research

A hypothetico-deductive approach permitted to build the conceptual research model and define hypotheses that were empirically tested.

Empirical context concerns international companies which outsource some activities, essentially prospecting and CSS, respectively through outbound and incoming call centers. The survey was carried out with CRM system users in an incoming call center for the CSS of an Internet Service Provider (ISP) with a platform of approximately 1000 operators.

Pre-inquiry was carried out for contents' ratification with 4 experts and 4 researchers (Master's and PhD students) in IS and CRM fields. The initial validation was thereafter tested again with 50 operators. For the final survey, a semi-guided questionnaire was addressed and 251 answers were usable.

Operators interviewed work for a call center working in French. In Tunisia, Arabic and French are the main languages used for professional activities. The survey was then administered in French and items were translated. Basic references were in English.

4. Tests, analyzes and results interpretation

Factor Analysis of Principal Components (FAPC) was used to validate the uniqueness of each variable and to check factors' rendering in the three conceptual levels. Thereafter, the Structural Equations Method (SEM) permitted to test in the same time, the different dependences between the variables. First analysis results are followed in table 2 below:

Applying conditions for maximum likelihood method in AMOS, the non multinormality of the sample imposed resorting to the bootstrap technique. The removal of aberrant observations didn't permit to have a significant Mardia.

Analyses carried out without and using bootstrap

on AMOS showed significant results ($p < 0.05$). The model reflects the data gathered and could be generally adjusted to the hypotheses validity.

Some validated sub-hypotheses match results of previous studies, others do not. Comparison of results are summarized in table 4 below:

Hypothesis		Validation			
		Current research	DeLone & McLean (92)	DeLone & McLean (02)	Roh & al. (05)
H1: Initiativ-IntrSucc	H1a: Sysqual – Usatisf	Yes	Yes	Yes	–
	H1b: Sysqual – Effectiveness	Yes	Yes	Yes	Yes
	H1c: Sysqual – Cusatisf	No	–	–	No
	H1d: Infqual - Usatisf	Yes	Yes	Yes	–
	H1e: Infqual – Effectiveness	No	Yes	Yes	Yes
	H1f: Infqual – Cusatisf	Yes	–	–	No
	H1g: Serqual – Usatisf	No	–	Yes	–
	H1h: Serqual – Effectiveness	Yes	–	Yes	–
H2: IntrSucc-ExtrSucc	H2a: Effectiveness-ImProf	No	Yes	Yes	Yes
	H2b: Usatisf – ImProf	No	Yes	Yes	–
	H2c1: Cusatisfc - ImProf	Yes	–	–	Yes
	H2c2: Cusatisfs - ImProf	No	–	–	No
H3: Initiativ-ExtrSucc	H3a: Sysqual – ImProf	Yes	Yes	Yes	No
	H3b: Infqual – ImProf	No	Yes	Yes	–
	H3c: Serqual – ImProf	Yes	–	Yes	–
H4: Effectiveness-CuSatisf	H4: Effectiveness-CuSatisf	No	Yes	–	–

Table 4: Confrontation of researches results

Results permit to conclude that general hypothesis HG: The integration of a CRM system has a positive impact on the profitability of the company is partially validated.

System quality, service quality and information quality seem to be significantly determinants for the improvement of company's profitability. Nevertheless, their intermediate effects come only by customer satisfaction regarding costs.

Table 6 displays the direct, indirect and total effects of each one of those independent variables:

	Direct Effect	Indirect Effect
sysqual	0,421	0,000
infqual	0,000	-0,077
serqual	0,416	-0,063
cusatisfc	-0,232	0,000
Total Effects		
	improf	
sysqual	0,421	
infqual	-0,077	
serqual	0,353	
cusatisfc	-0,232	

Table 3: Direct, indirect and total effects on profitability

Analysis of this effects show that only two variables of CRM initiatives (system and service qualities) have a direct effect on extrinsic CRM success. In addition, only information and service qualities have a significant indirect effect.

Success of the integration of a CRM system depends on system quality, service quality and information quality management, respectively by general priority order and with particular attention focused on the transposition of customer satisfaction regarding costs.

While analysing effects, the intermediate level (H4) was not checked. That leads to consider a parallel and not antecedent relationship between the mediating variables.

Conclusion

In the tunisian context, where CRM systems are not yet used on a large scale and mainly infiltrated by multinationals, we tried to define the main elements which permit to succeed CRM system integration in this particular economic context.

Results allowed to enrich reflections on interdependences between CRM system determinants and its intrinsic and extrinsic success. Analysis conducted permitted to identify direct and indirect causality relations that can explain the CRM system.

This research permitted to integrate measurement of customer satisfaction and user satisfaction within one model and the context of incoming call centers distinguished two levels of customer satisfaction. Results permit to success the integration of CRM systems in call centres in Tunisia.

However, some limits were inherent from the success measuring process complexity. It is mainly associated to the items choice. The empirical study involved only one incoming call center. In addition, the data gathered from the sample did not have a normal distribution, which calls for reconsidering the choice of the data analysis method. Also, we remark that 5 variables among 8 are defined by only one item to adjusted model; that represents a limitation which calls for reviewing the definitions of items.

New research paths could then be proposed. We can make a more deeped theoretical research about measurement tools for the IS success. A qualitative study could be done to define field-adapted items, that would provide better results for quantitative study. Research

could be either widened to a set of call centers working on incoming or outbound calls. It can involve contact centres and comparative studies could also be carried.

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Οι υποψήφιες εταιρίες

ΧΡΗΜΑ WEEK
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Επικρατούσα θετική διάθεση
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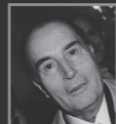
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