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Beliefs, Values and Attitudes of Portuguese Population and their Relationship with Human and Social Capital

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Abstract - **The main purpose of this paper is to describe and explain the economic values, beliefs and attitudes of the Portuguese population and how they are associated with behaviors linked to economic performance. It is based on a research oriented to three main goals: 1 - the description and explanation of the formation of economic values, beliefs, attitudes and behaviors, based on a questionnaire submitted to a national sample, stratified by regional areas; 2 - the identification of the existent linkages between these micro-sociological variables and regional and national economic performance (e.g. GDP, unemployment rates, inflation, investment, debt and wages); 3 - the exploration of the role of human and social capital as moderators between micro-sociological variables and a support for different types of economic values. In this paper we explore the third goal, offering a tentative typology of economic values' support.**

Keywords – *economic values, attitudes, behaviors, economic performance, human and social capital, Portugal*

1. Introduction

Studying economic values and beliefs and their relationship with attitudes and behavior has been common in most social sciences throughout the world, at least since the 1960s. However, Portugal remained very much outside this research program and, contrary to the majority of European countries or the United States, it still lacks a coherent an integrative research on economic values, beliefs and behaviors. On the other hand, the existing data (European and World Value Surveys, Eurobarometer or the Portuguese Statistics Institute) only offers a partial view of the individual's relationship with the economic system, namely consumer confidence or general ideas of trust. The studies already developed on this subject are normally restricted to the association of economic values and beliefs with socio-demographic characteristics, failing to include both the analysis of behaviors and the impact all these variables may have on economic performance indicators. The current study is intended as a first step towards a deeper comprehension of these phenomena.

The general purpose of this study was to describe and explain the economic values, beliefs and attitudes of the Portuguese population and how they were associated with behaviors linked to economic performance. The research was oriented to three main goals:

1. The description and explanation of the formation of economic values, beliefs, attitudes and behaviors, based on questionnaire submitted to a national sample, stratified by regional areas.

2. The identification of the existent linkages between these micro-sociological variables and regional and national economic performance (e.g. GDP, unemployment rates, inflation, investment, debt and wages).

3. The exploration of the role of human and social capital as moderators between micro-sociological variables and a support for different types of economic values.

In this paper we explore the third goal, offering a tentative typology of economic values' support.

2. Theoretical Frameworks

The study of economic values and beliefs and their relationship with attitudes and behaviors has a long tradition in social research. Political studies centered on the concepts of political and civic cultures (vg. Almond and Verba, 1965) paved the way to a large number of inquiries and surveys that tried to establish a set of expected relations between these variables, according to the levels of political development of each country. The standardization of groups of questions and the construction of attitudinal scales has also enabled comparative studies and the constitution of data sets which can be mobilized to pursue the analysis of inter-temporal dynamics.

Human capital and social capital are central to this research. Schooling level, taken as proxy for human capital, is generally considered as one of an important set of predictors of socioeconomic attitudes. At the same time, the aggregate effects of the growth of

human capital should be expressed in higher levels of development and be consistent with the emergence of less materialistic values. Human capital would be both a precondition for social and economic development in a particular society and a strong indicator of the emergence of a set of values associated with post-modernism and post materialist attitudes. Higher levels of education and training and the existence of a skilled and qualified workforce would be positively correlated with values and attitudes centered more on leisure and quality of life and less on monetary and economic issues.

Trust can be considered a proxy for the evaluation of social capital, even taking into account its obvious shortcomings. To start with, trusting others (the interpersonal basis of trust) as a general attitude is probably a poor predictor of economic activity.

Economic development is probably more correlated with high levels of institutional confidence than it is associated with a general feeling of trust towards significant others. It can be said that economic endeavors are more dependent on a strong institutional backing and the existence of enforcing judicial mechanisms than on the presence of strong ties between economic agents.

Low levels of interpersonal trust can limit the number of relevant associations but do not make them impossible. However, in terms of values and attitudes, it can be considered that trusting others, and having a positive image of them, predicts stronger levels of support for some types of social and economic policies expressed in welfarist policies.

The urban-rural divide and the coastline-interior cleavage are taken as good explanatory devices of the uneven development of Portugal. Taking this into account, it makes good sense to assess if there is a differentiation of populations towards development, in terms of attitudes and evaluation modes, according to their spatial distribution.

In European terms, Portugal is a latecomer both in the transition to post industrialism and in the transition to a more developed polity. These transitions were made possible by the revolution of 1974 which created a new political system and a new economic order. In this context it is relevant to study if post materialistic values lag behind the socioeconomic transformations or, on the contrary, if they run on parallel tracks. Assuming the existence of parallel evolutionary stages of economic development and economic attitudes, it would be interesting to determine whether Portugal, as a post industrial society, has already evolved into a post materialist society according to its dominant values. The mismatch between the economic order and the values that are allegedly needed to support it can identify a situation of recalcitrant modernization or weak post industrialism in which high levels of traditionalism tend to reduce the impact of the emerging post modern values. If this is indeed true we should expect the co-presence of values usually taken to be antagonistic and self contradictory espoused by the same groups.

In transition countries, the level of structural and behavioral coherence between values and the economic order should be lower than the one found in countries where the transitions are already consolidated. In social theory it is widely assumed that strong levels of consistency should be found between values and beliefs, and attitudes and behaviors. When it comes to the analysis of political or economic action, this presumed consistency is usually taken as the basis for constructing scales and typologies that mirror the left-right ideological divide. In this research we hypothesized exactly the opposite, expecting the presence of hybrid categories of values and individuals simultaneously espousing values usually taken to be contradictory, but that fit the inner logic of citizens facing transitional polities.

3. Empirical Results

3.1 Sample Construction and Description

The sample was constructed, based on previous research (Pereira et al, 2008), obeying to a double idea of being representative at national level but also at a regional level, reflecting the wide development differences between Portuguese municipalities in economic, social and cultural terms. So, the sample was constructed in two stages – first by choosing the representative municipalities by way of four clustering instruments (rurality, accessibility, income, and renovation indexes), and then by choosing the individuals in each selected municipality, according to levels of education, income, profession type and other general socio-demographic characteristics that mirrored the previously known municipal distribution. The total sample was divided in four clusters:

Cluster 1 was characterized by its low rurality, high accessibility, high income and medium renovation;

Cluster 2 was characterized by its medium rurality, medium accessibility, medium income, and medium renovation;

Cluster 3 was characterized by its high rurality, low accessibility, low income, and low renovation;

Cluster 4 was characterized by its medium rurality, medium accessibility, low income, and high renovation;
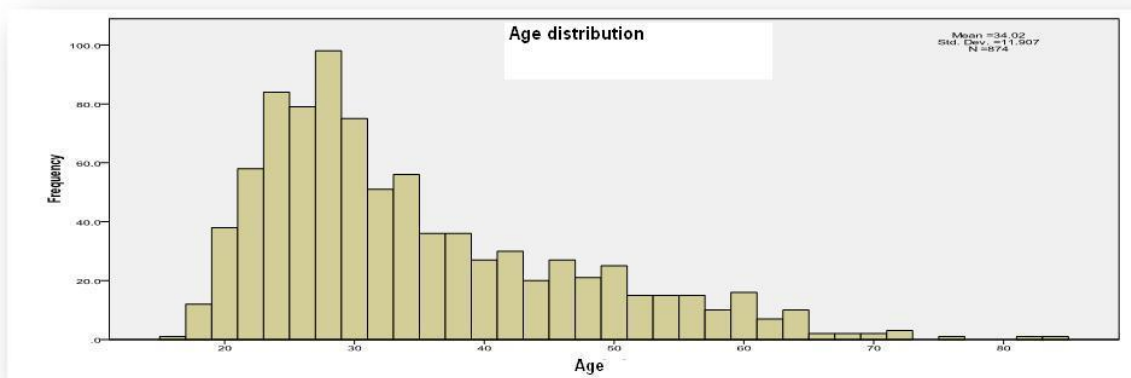
Figure 1 - Age distribution in the sample (absolute frequency)
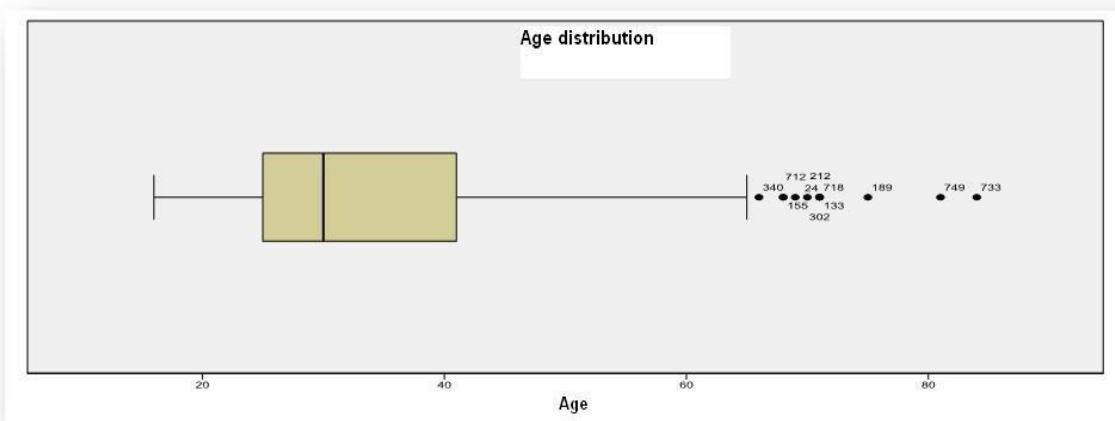
Figure 2 - Age distribution in the sample (Box plot)
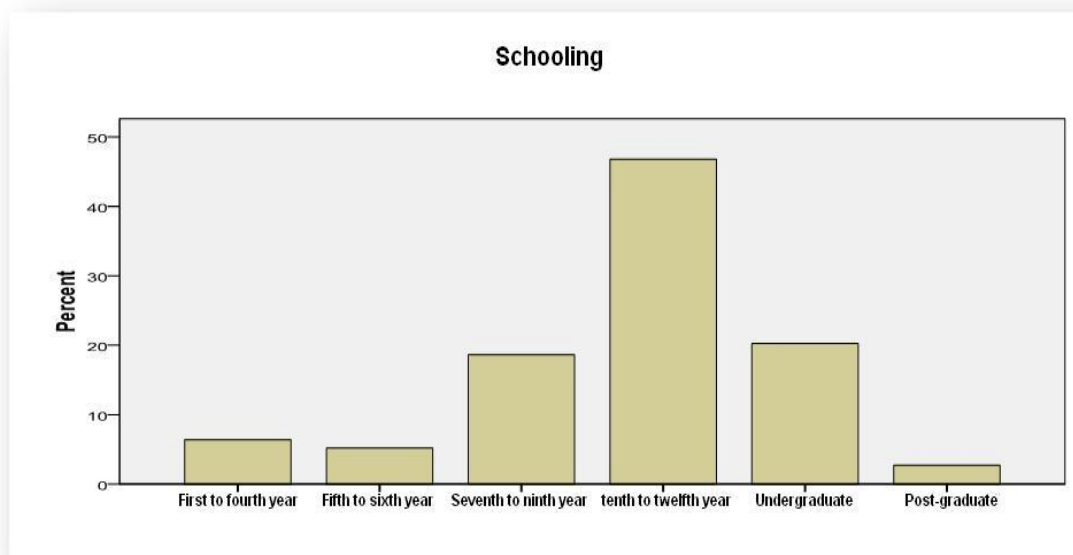
Figure 3 - Relative frequency of participant's schooling

study was 1000 individuals of which 948 responded to the written questionnaire that was presented between April and September 2009. The number of validated answers was 792.

The gender composition of the sample was 593 women (64%) and 333 men (36%). The minimum age of participants was 16 years old and the maximum 84 years old, with an average age of 34

and there are 11 outlier participants with ages above 65.

The school level of participants (see Figure 3) includes all the educational grades, from primary (6,4%) and preparatory (5,2%) teaching [1], to post graduated studies (2,7%). Most of the participants have a complementary graduation, 10th - 12th grades (46%), followed by university graduation (20,3%)
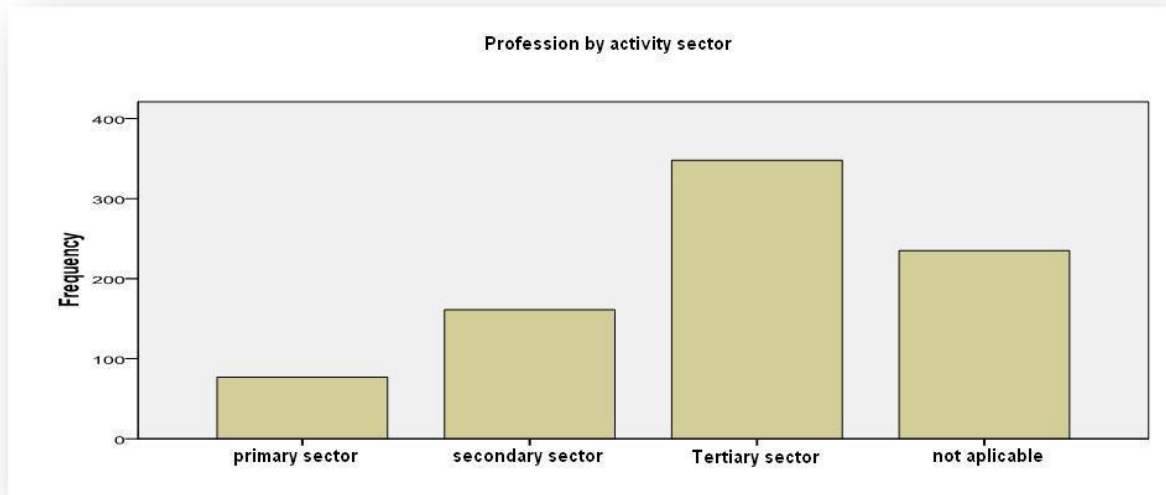
Figure 4 - Absolute frequencies of participants by activity sector
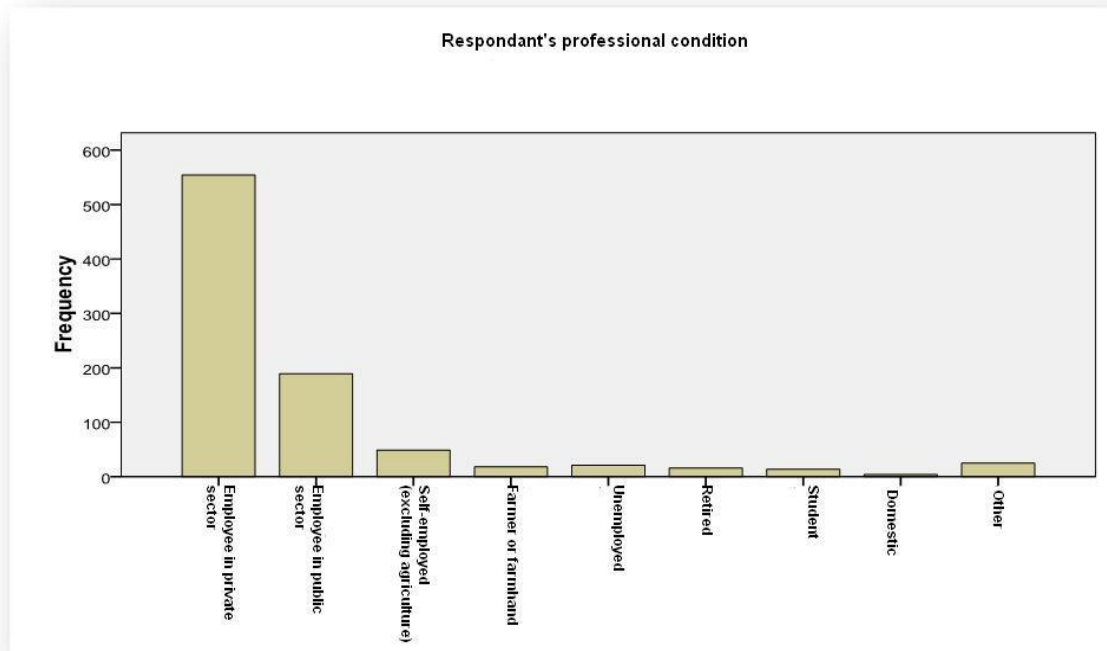
Figure 5 - Absolute frequencies of participant's social class

(Standard Deviation of 11, 9). The age distribution of participants is presented in Figures 1 and 2.

In these figures we can see that about one half of participants have ages between 25 and 40 years old

[1] In Portugal, "primary" teaching corresponds to the first 4 years of formal schooling and "preparatory" teaching corresponds to the 5th and 6th years.

and secondary teaching, 7th - 9th grades (18,6%).

As we can see in Figure 4, about one half of participants described themselves as tertiary workers (42,4%), followed by secondary (19,6%) and primary (6,4%) workers. A significant part of individuals does not classify itself in any sector of activity (28,6%).

Concerning the socioeconomic class (see Figure 5), participants reported to be mainly private (62,2%) and public sector employees (21,2%). The other individuals divided in self employed workers (5,5%), agriculture workers (2%) unemployed (2,4%), retirees (1,8%), students (1,6%), home workers (0,4%) and others (2,8%).

about the economy (cf. Heaven, 2001; Bastounis et al., 2004).[2] More specifically, the questions resulted from the "Economic Values Inventory" (O'Brien and Ingels, 1987); the "Economic Beliefs Scale" (Leiser and Briskman-Mazliach, 1996); the "Economic Future Scale" (Furnham, 1996, 1997); the "Materialism Scale" (Belk, 1984); the "Money Attitude Scale" (Yamauchi and Templer, 1982); the "PANAs scales" (Watson *et al*, 1988) and the "Attitudes to Debt" (Lea et al., 1985). In terms of economic behaviour, questions were asked concerning savings, investments, consumption and credit use. Human capital was measured by education levels and social capital was proxied by general trust questions and associativity and perceptions of

Table 1 - Respondent's socioeconomic class

	Employee in private sector	Employee in public sector	Self-emp (exclude. Agric.)	Farmer or farmhand	Unemployed	Retired	Student	Domestic	Other	**Total**
Prim. Sec.	42	10	10	2	1	3	2	2	3	**75**
Seco. Sec	112	29	4	3	2	1	1	0	1	**153**
Terc. Sec	218	84	16	6	4	1	0	0	4	**333**
n.a.	126	41	10	4	13	9	10	2	16	**231**
Total	**498**	**164**	**40**	**15**	**20**	**14**	**13**	**4**	**24**	**792**

However, a more detailed analysis comparing the sector of activity and the socioeconomic class of participants shows some discrepancies between these results, probably revealing ignorance about the precise meaning of these categories. In Table 1, we can see that home workers and students included themselves in sectors of activity. There are also seven unemployed persons and five retirees self-classifying in activity sectors, probably, but not for sure, in their corresponding previous jobs. Six agriculture workers attributed themselves to services and four n.a. (non applicable). Among the employees, 126 in private sector and 412 in public sector consider not applicable to them any category. This decision may be wrong and should correspond to the tertiary sector, but also about it is not possible to be completely certain.

3.2 The Questionnaire

The questionnaire was built, taking into consideration previous research on the relationship between psycho-sociological variables and economic behaviour and also the centrality of lay thinking

associativity.

3.3 Economic Values and Attitudes

One first point worth mentioning (see Figure 6) are the very high levels of both Egalitarianism and Anti-tax evasion, which in itself somehow tends to blur the significance of these variables: since everyone officially agrees in which concerns these questions, the results tend to be somewhat irrelevant. Next in importance, come the relatively high levels of support for welfare state and business, while anti-system values and fatalism are comparatively weak. Even lower are anti-price regulation and anti-unions values.

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[2] The Questionnaire is available on request.

importance, come the relatively high levels of support for welfare state and business, while anti-system values and fatalism are comparatively weak. Even lower are anti-price regulation and anti-unions values.

In order to identify patterns concerning economic values and attitudes, we have proceeded to a statistical treatment (correlation analysis) of the answers given to the following questions (taken as proxies to the attitudes mentioned between

Figure 6: Support for Economic Values
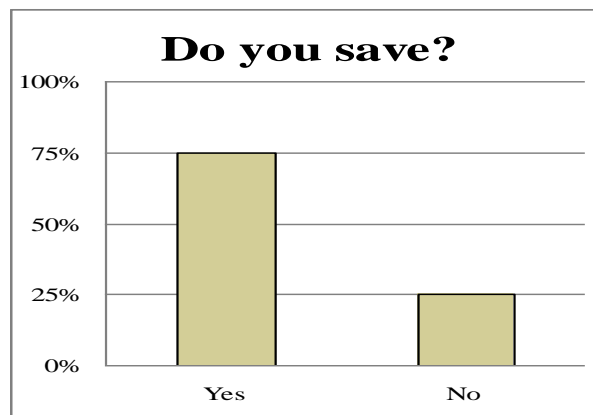
Figure 7: Saving
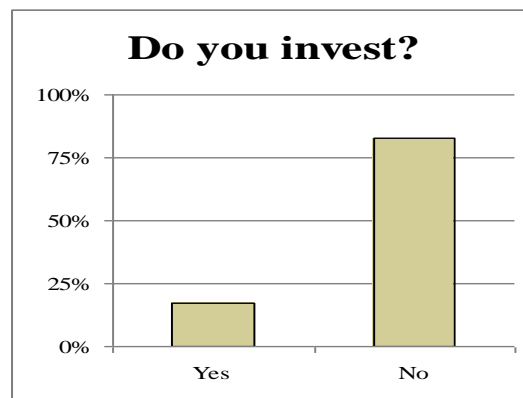
Figure 8 - Investing

Another aspect worth mentioning is the fact that a clear majority (around 75%) declares that they save (Figure 7) while only a small minority (roughly 17%) claims to invest (Figure 8). This seems to indicate a strong element of risk aversion but also some lack of ability for personal financial management.

parenthesis): 1 - Our society owes much to the contributions of business (Pro Business); 2 - It should be the duty of government to be sure that everyone has a secure and decent standard of living (Pro Welfare State); 3 - The unemployed shouldn't blame themselves for their situation; it's the economic

system's fault (Anti Economic System) ; 4 - Getting ahead is mostly a matter of luck (Fatalism); 5 - It's not the business of the government to control prices (Anti Price Regulation) ; 6 - Unions are too powerful (Anti Trade Unions); 7 - We need a way to make incomes more equal in this country (Egalitarianism) ; 8 – People who avoid paying taxes hinder their fellow citizens (Anti-Tax Evasion).

Considering the results shown on Table 2, we can identify groups of affinity, which are based in pairs of significantly correlated variables. The more striking cases are: a) anti economic system and fatalism (correlation coefficient of 0,342), which suggests a group we can call Hippies; b) egalitarianism and anti tax evasion (0,240), which is evidence of a group we call Levellers; c) anti price regulation and anti trade unions (0,231), pointing to a group of Free marketers; d) fatalism and anti-price regulation (0,205), suggesting the existence of a group we name True fatalists; e) 2 pro Welfare State and anti Economic System (0,172), a likely group of Welfarists; f) 3 anti economic system and anti price

regulation (0,166), suggesting a group of Discontents. Notice that since these groups have been identified on the basis of pairwise correlations, they may be partly overlapping.

Worth highlighting are the considerably high positive correlations that variable 3 – anti Economic System has with several others, namely: fatalism; pro Welfare State; anti price regulation and egalitarianism. It has also a slightly negative correlation with anti tax evasion.

Some of the previously mentioned correlations are clearly compatible with conventional economic wisdom, viz egalitarianism with anti tax evasion or (in an opposite sense) anti price regulation with anti trade unions, while others indicate ambiguous inclinations, such as anti economic system with anti price regulation, if not clear incoherence, as in the case of anti economic system with pro tax evasion. These shifting levels of coherence may partly reflect different levels of economic literacy, but it is also reasonable to assume they express behavioral inconsistency of common people.

Table 2 - Correlations between Questions 1-8

Correlations between Questions 1- 8.								
Q8	,077[*]	0,039	-0,014	-,076[*]	-,074[*]	-0,043	,240[**]	1
Q7	-0,013	,150[**]	,100[**]	0,031	-,100[**]	-,101[**]	1	
Q6	0,042	-0,057	0,061	0,058	,231[**]	1		
Q5	,089[**]	-,092[**]	,166[**]	,205[**]	1			
Q4	0,032	,115[**]	,342[**]	1				
Q3	0,04	,172[**]	1					
Q2	0,022	1						
Q1	1							
Q	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**

3.4 The Importance of Human Capital

The influence of human capital (HC) in economic and social behavior is the subject matter of a long tradition of economic literature (Schultz, 1960;

Becker, 1964, Savvides and Stengos, 2009). In this paper we consider human capital as formal education and quantify the correlations between HC and the eight variables mentioned above (see Table 3).

Table 3 - Correlations between Questions 1-8 and Schooling

Correlation Questions/schooling								
Schooling	-0,052	-0,048	-0,197	-0,097	-0,134	0,003	-0,026	0,049
Q	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q8**	**Q8**	**Q8**

The most relevant aspects to underline have to do with the fact that education correlates relevantly, if negatively, with anti price regulation, fatalism and anti economic system. If the last two correlations are expectable, the first one may be considered somewhat awkward.

The fact that all the other five correlations have values close to zero is also in itself relevant, although a bit of a disappointment for those assuming a strong importance of human capital.

3.5 The Role of Social Capital/Trust

More recently, the role of social capital has been consecrated as distinct field of research, originating

an extended literature (Putnam, 1995; 2000). Here we consider social capital as measured while trust in others. Three levels of trust are identified: people of the same parish; people of the same municipality and people of the same country.

More vehemently than in the case of human capital, the main result we have come to indicate low levels of correlation of all three types of trust with the eight original variables, none of them statistically significant (see Table 4).

Table 4- Correlation between varieties of trust and questions 1-8

Correlations between Questions and varieties of Trust								
Trust 3	,014	-0,014	0,058	0,01	-0,039	-0,044	0,022	0,037
Trust 2	-0,042	0,018	0,06	0,026	0,021	-0,016	0,052	,077*
Trust 1	-0,01	0,024	-0,002	0,047	-0,03	-0,021	0,046	0,063
	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1

Although we must emphasize the fact that we have taken social capital strictly as trust, the results somehow infirm what one might expect based on the literature above. This aspect is reinforced by the fact that all three types of trust have close to zero correlation values with education (see Table 5).

Table 5 - Correlation between varieties of trust and varieties of trust with schooling

Correlations between varieties of Trusts			
Trust 3			1
Trust 2		1	0,593
Trust 1	1	0,737	0,416
	Trust 1	Trust 2	Trust 3
Schooling	0,034	-0,043	0,008
Correl Trust/Schooling			

However, as also shown in Table 5, all three types of trust strongly correlate with each other. This aspect may be assumed as expectable, notwithstanding the fact that some research lines have suggested a trade-off between trust concerning close and distant social circles.

4. Concluding Remarks

As way of conclusion, we ought to recapitulate by remembering the considerable margins of incoherence detected in this study, concerning either

the relationships between values and beliefs or the ones regarding attitudes and behaviors. Part of the explanation for that may indeed lie, as mentioned above, in the merely transitional character of Portuguese society, with only imperfectly post-materialist (or post-modern) traces. On the other hand, however, we can also deem how much these incoherencies may be analytically turned upside down, that is to say, taken as an expression of a "different" modernity, or of its specificities, and therefore appealing to a broader frame of analysis

concerning the processes of change in which nowadays societies are involved at large, instead of simply be thought of as expressions of "transition", i. e., weaknesses and incompleteness. Concerning this subject, it is surely worth mentioning the points made in classical study by Alexander Gerschenkron (1962), referring to the specificities of processes of industrialization and economic development occurred after the British one. We must indeed, in many cases, enlarge and enrich our global vision of social processes, instead of merely expecting for the strict repetition of patterns, and despair or blame "backwardness" or "transition" when they simply do not emerge…

Within this context, an important element to consider is also the fact that the main categories we came up with in section 3.3 are mostly impressive ones, categories that so to speak "popped out" of the data rather than being previously prepared by us. However, the statistical treatment of these data remains rather preliminary, since we didn't advance into cluster analysis. At any rate, the basic traces identified do really seem quite relevant: surprisingly high levels of egalitarianism and anti tax evasion sentiments, more modest support for both business and welfare state, quite low levels of anti-unions and anti price regulation dispositions. In a certain way these results seem to defy the common sense about the positioning of social actors towards economic categories.

One other aspect worth mentioning concerns the fact that we did not deepen into the regional-based study of our sample. As it was, we have limited ourselves to take a sample representative of the totality of Portuguese population according to the variables presented (see above), and considering the proportions of each identified region, but did not proceed to analyze the differences between the various regions.

Finally, one word recalling the patently ambiguous correlations identified concerning human capital and the rather innocuous influences that social capital apparently maintains with most traces of economic conduct. In spite of partly disappointing, these officially "blurred" results surely appeal to a reformulation of analytical frameworks allowing us to identify the really relevant focuses, and proceed to the necessary recombination of ideas and judgments. Those will most certainly be goals of ours in research ahead.

References

[1] Almond, G. A., Verba, S. (1965), *The Civic Culture*. Boston, MA: Little, Brown and Company.

[2] Bastounis et al (2004), Psychosocial variables involved in the construction of lay thinking about the economy: Results of a cross-national survey. *Journal of Economic Psychology*. 25, 263-278.

[3] Becker, G. (1964), *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*. Chicago, University of Chicago Press.

[4] Belk, R. W. (1984), Three Scales to Measure Constructs Related to Materialism: Reliability, Validity, and Relationships to Measures Of Happiness, in *Advances in Consumer Research* Volume 11, eds. Thomas C. Kinnear, Provo, UT: Association for Consumer Research, Pages: 291-297.

[5] Coleman, J.S. (1988), Social capital in the creation of human capital. *American Journal of Sociology* 94, pp. 95–120.

[6] Fukuyama, F., (1995), *Trust: The social virtues and the creation of prosperity*, Penguin, London.

[7] Furnham, A. (1996). Attitudinal correlates and demographic predictors of monetary beliefs and behaviours. *Journal of Organizational Behaviour*, 17(4), 375-388.

[8] Furnham, A. (1997). The half full or half empty glass: The views of the economic optimist vs. pessimist. *Human Relations*, 50(2), 197-208.

[9] Gerschenkron, A. (1962), *Economic backwardness in historical perspective, a book of essays*, Cambridge, Massachusetts: Belknap Press of Harvard University Press.

[10] Heaven, P. (2001). Economic beliefs and human values: Further evidence of the two value model? *The Journal of Social Psychology*, 130(5), 583-589.

[11] Inglehart, R. (1997), *Modernization and Postmodernization*. Princeton, Princeton University Press.

[12] Lea, S. E. G., Webley, P. and Walker, C. M. (1995), "Psychological factors in consumer debt: Money management, economic socialization, and credit use", *Journal of Economic Psychology*, Volume 16, Issue 4, December 1995, Pages 681-701

[13] Leiser, D. and Briskman-Mazliach, R., (1996). The economic model questionnaire, *Ben-Gurion University*, Beer Sheva.

[14] O'Brien, M. U. and Ingels, S. J. (1987), The economic values inventory, *Journal of Economic Education*, 18, 7-17.

[15] Pereira, E., Pereirinha, J., Passos, J. (2008) Desenvolvimento de índices de caracterização do território para o estudo da pobreza rural em Portugal Continental, *Revista Portuguesa de Estudos Regionais*, 21: 1-30.

[16] Putnam, R. (1995), Bowling Alone: America's Declining Social Capital". *Journal of Democracy* 6 (1): 65–78.

[17] Putnam, R. (2000), *Bowling Alone: The Collapse and Revival of American Community*. New York: Simon & Schuster.

[18] Savvides, A. and Stengos, T. (2009), *Human Capital and Economic Growth,* Stanford University Press.

[19] Schultz, T. (1960), Capital Formation by Education, *Journal of Political Economy*, 68, 571-583.

[20] Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of Positive and Negative Affect: The PANAS Scales. *Journal of Personality and Social Psychology, 54,* 1063-1070.

[21] Yamauchi, K. T., and Templer, D. I. (1982). The development of a money attitude scale. *Journal of Personality Assessment*, 46(5), 522-528.

Hunting Rights and Conservation:
The Portuguese Case

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Abstract **- Hunting and game-preservation are interrelated. There are two fundamental traditions in the legislation on hunting property rights: the Romanic tradition and the Germanic one, with different consequences in terms of resources use and conservation.**

The Economic Theory of Common Resources has been applied to provide conclusions about the management and conservation of hunting resources. In this paper, we derive a model of hunting management, adapting the Gordon/Schaefer fisheries model. The conclusions of the model are confronted with Portuguese hunting regulation.

Keywords *- "Tragedy of the Commons", hunting, game-preservation, res-nullius.*

1. Introduction

Hunting (whether for food or for sport) marked all the periods of History, in all latitudes, cultures and civilisations (Carmo, 2000). But the traditional obscurity of this sector leads to the relative poor attention, in the context of the Natural Resource and Environmental Economics: despite the social and economic importance of the sector in countries like Portugal, the literature on hunting is scarce.

In a relevant paper from the 90s, Hasenkamp (1995) derived a model of hunting management and conservation and concluded that hunting and game-preservation were interrelated: hunting must respect the intentions of game-preservation, and game-preservation must rely on hunting as one method to achieve its intentions. In the paper, the Economic Theory of Common Resources is applied to the problem to provide conclusions. What is curious is that these conclusions are reflected in the existing relevant legal hunting setting in Germany. That is, German Law contains regulation that confronts the hunter with the objectives of hunting preservation and held him the responsibility for pursuing these goals.

By the contrary, in Portugal (and other Latin countries), the fundamental debate in this domain always turn around the overexploitation of hunting resources and the dissatisfaction of hunters with hunting regulation, especially with that relates to hunting property-rights and access conditions to hunting grounds.

Our issues are the following: What are the differences between Portuguese regulation and the Germanic one? With respect to hunting regulation, is the legislator confronted with different conceptions or principles? What difference does it make? What are the economical effects of this possible distinct legal tradition?

The structure of the paper is the following:

First, we compare two conceptions of hunting property rights: the Roman conception and the German conception.

Then, we derive a model of hunting management and conservation. Analysis of the model leads us to conclude about the relation between the property-rights regimes and the efficient use of hunting resources.

Finally discussion of Portuguese hunting regulation takes us to conclude about our Roman tradition and hunting management consequences.

2. Romanic Versus Germanic Legal Tradition

Ortega y Gasset formulated the hypothesis of being printed, in the man's sub-conscience, his hunter past.

The juridical evolution of the property-rights regimes of hunting and the discipline demanded for the activity can help to understand the attitudes of the legislator and the proposed regulation. Along the centuries, two systems, or conceptions, about hunting property-rights, were confronted: the Roman conception and the Germanic conception.

The Roman conception states that the wild animals constitute res nullius, things without owner that all men can appropriate by *ocupatio*, the only title of property acquisition on the hunted wild animal. To this conception, the classification of *free land* implicates that the hunter has the freedom of access to the hunting resources in other's land, although respecting imposed norms.

Of course, as the agriculture was organised, the idea of game reserve appeared. And, as a consequence, the twin idea of extending an ownership right to the wild animals living in someone's land was developed. But, indifferent to such habits, the Roman law maintained to the whole wild animal the consideration of freely access. The property of the wild animal owes to the hunter who captured it, to the land's owner being just reserved the right of excluding others from hunting in their lands. It's the recognition of "*res- nullius*" nature of hunting resources and hunt as a national value.

This attitude is understandable. Romans saw the activity in a circus perspective. This attitude made hunting a "frivolous" occupation, not an economic activity. Hunting was identified with the imperial virtues of physical and paramilitary education. Hunting, horse-seated, was a distinctive form of the resistance to the barbarian activity of hunting "as massacre" (Carmo, 2000). This vision was incompatible with the private property. On the contrary, it suggested a noble fight between the man and the wild nature. And, only if nature was identified with something of absolutely free, this fight made sense in ethic terms.

The Germanic conception considers the right of hunting due to a privilege (feudal type) of the landlord. Hunting right is clearly linked to the property right on land. The landowner is entitled of disposing of what is "*his property*", including the hunt.

There has been an important debate among defenders of the two conceptions.

The defenders of the Roman regime oppose the argument that the Germanic conception is artificial in its foundations. It does not solve the management and conservation problem in the areas of small property because the hunt has natural mobility and can be born and feed in a hunting ground, live in another and be captured elsewhere. So, the determination of the property is impossible.

They also argue that, to be applied with the whole rigidity, this conception would result in the complete extinction of all the free lands, transforming the territory in an immense game reserve where the hunters without land would not have access. This could be identified as a "true abuse of right". In the extreme situation, the "owner" could impede the access and could, also, destroy or take advantage of the resources, attempting against a public wealth that imported to safeguard. So, the Government must limit such ends.

By the contrary, the Romanic conception sees hunt as a common, res-nullius good; the property right appears in the own moment of the capture. This conception has, to its favour, some arguments of value:

- The mobility of the hunt inter-properties as a gift of nature;

- The private property carries out a social function and it can be the case that the Government wants the landowners to support the social costs of creating the species destined to collective use.

The defenders of the German conception put in evidence the problem of the conservation of the species. The rationale of this argument approaches, in essence, the theoretical economic discussion of the Natural Resource Economics when approaching the Common Property problem and the so-called "Tragedy of the Commons". The exploitation in regime of open access will lead, unavoidably, to the situation of overexploitation of the resources, due to the non-existence, or vague stance, of property rights.

On the contrary, to the defenders of the privatisation of hunting, the optimal solution can arise by trusting in the private owner interest. Landowners will use the resources in an inter-temporal logic that intends to maximise the present value of benefit stream of hunting, along the time. In his land, each landlord can work as a "sole owner" promoting the efficiency in the resource exploitation and conservation.

This is what we intend to demonstrate with the formal bioeconomic model of hunting management that we develop and present in the next point.

3. A Model of Hunting Management

To suit the purpose of modelling hunting activities and exploring the issues of hunting resources management and conservation, Hasenkamp (1995) adapted the model of Dasgupta and Heal (1979).

Our proposal is different. We adapt the Gordon/Schaefer model. Becoming from Fisheries Economics, this is a very useful model to explain the market characteristics and agents behaviour, in the general common property case.

In this presentation we only approach the static version of the model to highlight the fundaments of hunting mismanagement when we consider the open access situation. A dynamic version of the model – forthcoming - will help, also, the correct explanation of possible regulation solutions for the common property problem. These economic tools switch, in its essence, the traditional answers, to the externalities problem, of Pigou and Coase.

The central point in the Gordon (1954) paper is that fish are difficult to observe (except upon capture) and mobile (often travelling great distances). Consequently, these resources have provided excellent examples of resources in which the costs of attempting to establish property rights are perceived as exceeding, by a wide margin, the benefits that might be derived there from.

Gordon argues that, if a common property fishery is subject to no government regulation and the fishing industry is competitive, there will be inevitable market failure: the fishery will be expanded to the point that economic overfishing and overcapacity will occur (Munro, 1982).

The similarities with the hunting case are obvious.

Suppose a large area, for example, a municipality. We assume that the disposable land is subject to two different activities: agricultural use and hunting.

If we want to design an acceptable economic model of hunting, we must introduce, in its foundation, a biological model of hunting resources growth.

In the Gordon article, the underlying biological foundation is a variant of Schaefer (1957) model. In our model, the populations' dynamics can, also, be easily described with a "Macro-Biological Approach". A hunting resource population or biomass will, if not subject to human capture, grow, in terms of weight, both as a consequence of the recruitment of new individuals and as the result of the growth of individual wild animals in the population. Natural mortality will act as a check on growth. If we assume stable environmental conditions (especially, if we do not introduce men as predators), along the time, the biomass will approach a natural equilibrium level at which net growth is zero.

If we do not attempt to distinguish among the factors influencing net growth, the growth of the biomass can be viewed as a function of the biomass itself, and the population dynamics can be modelled by a very simple differential equation:

$$G(x) = \overset{\bullet}{x} = \frac{dx}{dt}$$

x denotes the biomass and $G(x)$ represents the regeneration capacity associated with every level of the stock.

The relation between the rate of growth and the level of the stock is not monotonic. As in the Schaefer model, we'll have a quadratic function:

$$G(x) = r\, x\, (1 - x/K)$$

K denotes the carrying capacity and r, constant, denotes the intrinsic growth rate.

When integrated, we are facing the popular Lotka/Volterra logistic equation of population dynamics.

When we introduce the men action of capture/hunting, the first equation is modified:

$$dx/dt = G(x) - H(t)$$

$H(t)$ denotes the hunting rate.

The hunting production function is given by:

$$H(t) = h\, F(t)\, x(t)$$

$F(t)$ denotes the venation/hunting effort at time t (a kind of "capital-jelly" measure of the flow of labour and capital services devoted to hunting activities; this could be evaluated, for example, in terms of hunting hours), and h, constant, denotes a capture-ability coefficient measuring the different capture conditions between hunting grounds.

If the resources are being captured in a sustainable basis, then $dx/dt = 0$ and $H(t) = G(x)$.

Hence, $G(x)$ can be viewed as the sustainable yield associated with a given biomass level. This also drives us to the well-known "Maximum Sustainable Yield" Principle proposed by biologists as an orientation rule for resource use. The growth rate is a quadratic function. So, there is a stock where the regeneration capacity is maximised, and that is the stock that makes possible to maintain indefinitely a maximum capture rate. The management objective should be to drive the biomass to that level and, afterwards, to capture, every year, the associated growth of the stock.

Since $H(t)$ is a function of F, as well as x, one can establish the sustainable yield/ venation effort relationship: $Y = \alpha F - \beta F^2$,

Y denotes sustainable physical yield, with $\alpha = h\,K$ and $\beta = h^2 K/r$.

In fact, if capture is taking place on a sustainable basis we have:

$$h\, Fx = G(x) \quad \text{and} \quad h\, F\, x = r\, x\, (1 - x/K).$$

Then, we can derive the expression $x = K\,(1 - h/r\, F)$ and, by substitution, we find an equation expressing sustainable yield as a function of F:

$$Y = h\, F\, K\, (1 - h/r\, F) = h\, K\, F - (h^2 K/r)\, F^2$$

With the biological model complete, we can introduce prices and costs.

We assume that both the demand for captured hunting resources and the supply of hunting effort are perfectly elastic.

The cost function can be expressed as the simple equation:

$$C = c\, F$$

We assume that the total cost is linear with effort. The constant c denotes unit cost of effort.

Sustainable revenue is represented by pY, where p is the unit price of hunting. It has, also, a quadratic form. Note that total cost is to be interpreted as the total cost of capturing the sustainable yield.

We can now solve, graphically, the model and analyse the behaviour of the "industry" (see Figure 1):
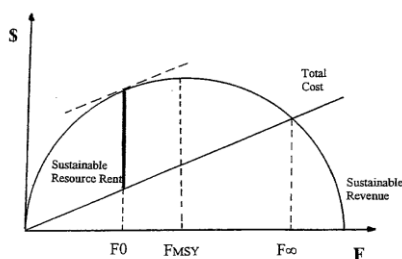
Figure 1

The main conclusions are:

- If hunting was managed by a "sole owner", the hunting would be stabilised at the point where sustainable resource rent (sustainable revenue less total cost) is maximised, that is, F_0. In this situation, hunting resources are managed in a socially optimal manner and, at that point, the marginal cost and the value of the marginal product of venation effort are equal. If hunting effort expands beyond F_0, overexploitation of the resources occurs.

- If hunting activities take place in a regime of Open Access, that is, in a *res nullius* basis, and if hunting is unregulated and competitive, there is no landlord to appropriate the resource rents generated by hunting. Thus, if hunting was at the point where resource rents are maximised, F_0, the "industry" would be enjoying super-normal returns and new hunters would be attracted to enter the hunting ground. Hunting effort will expand, leading to overexploitation of biomass. In this case, hunting would not be in equilibrium until it had expanded to the point where total costs are equal to total revenues, that is, until resource rent had been fully dissipated. At this point, F_∞, the marginal social cost is different from private marginal cost. This "bionomic equilibrium" (as Gordon used to call it) reflects the existence of externalities in the hunting process, and it's a case of market failure.

Note, also, that even the principle of "full resource utilisation", proposed by the biologists, is, possibly, less-conservationist than it is pretended (and needed). In fact, the level of venation effort associated with maximum sustainable yield (F_{MSY}) can be higher than the effort associated with the "economic optimum" (F_0).

The central idea can be stated as follows:

In conditions of free access and competition the market leads to non-optimal solutions in resource use. The "res nullius" nature of the property-rights regime and the presence of externalities in the capture, and their effects, especially the complete dissipation of resource rents and the dynamic effects on the stocks, lead to market equilibrium solutions that implicate overexploitation and overcapacity.

There is nothing like an "invisible hand", in such case. Some kind of regulation is needed. Agents must internalise the external effects. Otherwise resources will be overexploited and, perhaps, irreversibly becoming extinct. In this sense, it seems that the followers of German conception are in the right side. But of course there are also other dimensions of the problem that must be discussed. One of them is the equity issue.

4. The Portuguese Case

The Portuguese case is curious. Hunting was always practised in Portugal and covered by the Latin jurisprudence, although hunt resources have been considered as inherent to the land's domain. To this jurisprudence wild animals are things without owner that all men can appropriate by *ocupatio*. This is the only title of acquisition of the property on the hunt.

This tradition of open access is the root-cause of hunting depletion. But, at the same time, the legislator sees it as a form of giving the hunters without land the possibility of enjoying this activity. This is compatible with the Portuguese tradition that attributes something like a universal privilege to the right of hunting. Our legislators wrapped up in the discussion between Romanic and Germanic conceptions. The confrontation between the defenders of these regimes impresses because it's a case of a country where the tradition of "the freedom of hunting" almost attributed *a personality right* to the right of hunting. That is, the issue of equity is also considered in the Portuguese legislation. In fact, the capacity of entering one's land only to capture wild animals which "have no owner, only pertaining to *Free Nature*", give the common people/hunter the sensation that they are equal face to the gifts of Nature.

Note also that the Portuguese tradition is, obviously, Roman, but it doesn't stop revealing interesting and original signs.

After some original mixtures (even introducing some reserve areas), with the approval of the *Civil Code of Seabra* (1868) the Romanic tradition was absorbed in a very clear mode. In the title I (article 383) and in the title III (of the territory occupation), hunting is designed as *res-nullius*. The Code settles down the legal principle that "it is bid to all, without distinction, to hunt the wild animals, in conformity with the administrative regulations that determine the way and the time of hunting".

The article 388 of the Code recognised the property-right to the hunter, after having captured the animal. But, the hunting sector was complemented later with hunting regulation, national and municipal regulations, consisting of hunting seasons, prohibitions of destruction of nests and habitats, fines, and so on.

The actual Portuguese Hunting Law (1999) is a compromise between the Roman tradition and the necessity of hunting preservation.

In the context of evident overexploitation of hunting resources, the legislator maintained the free access principle in the so–called municipal hunting zones. This principal is also guaranteed in the designed national hunting zones but, for these areas, the fundamental characteristic is the state management with conservation and scientific research purposes.

At the same time, the hunting legislation created associative and tourism-hunting zones where the access rules are restricted. The objective is to held the hunters the responsibility to achieve the objectives of sustainable use and protection of the species.

Focusing on the types of property-rights relevant to common property (see Coelho, Filipe and Ferreira, 2010) it seems that we are now trying a perfect mixture of "res-nullius", "res-publica" and "res-communes".

Especially this last proposal, switching the ideas of Elinor Ostrom, seems to have a great domain for future development. Ostrom studies are fundamental in the substitution of the "Tragedy" metaphor to the more interesting "Drama of the Commons". Of course we'll have tragedies, in the free access situation, but sometimes we'll have also reasons to laugh. Ostrom stresses that a commons can be well governed and that most people, when presented with a resource problem, can cooperate and act for the common good. "Co-management" and self–regulation are the keys for sustainable resource management. That is also the case for hunting.

5. Final Remarks

Our research suggests the following final remarks:

Despite the traditional "opacity" of hunting world, this is a fertile field for Social Sciences investigation, Economics included. A fundamental problem stands in the fact that there is an "unfortunate tradition", even in theoretical grounds, of failing to recognise the critical distinction between the *true* common property (res communes) and non-property (res nullius). This situation blurs analytical and prescriptive clarity. Property refers not to an object but rather to the benefits' stream that arises from its use. In the essence of property concept there is a social relation. So, there's nothing inherent in the resource itself that determines absolutely the nature of the property rights. The use of the term "Commons", in reference to resources as the hunting case, is ambiguous.

The only thing that we can positively affirm is that, in conditions of open access and competition, the hunting market leads to non-optimal solutions in resource use. The "res nullius" nature of the property

regime and the presence of externalities in the process of capture, lead to the complete dissipation of resource rents. So, the market will be driven to hunting equilibrium solutions that result in overexploitation of hunt resources and overcapacity (that is, "the Tragedy of the Commons").

Portugal has a long Roman tradition in legal hunting setting. This tradition of open access is the root-cause of hunting depletion. But the legislator sees it as a form of giving the hunters without land the possibility of enjoying this activity. This is compatible with the Portuguese tradition, which almost attributes a *personality right* to the right of hunting. The actual Portuguese Hunting Law (1999) is a compromise between the Roman tradition and the necessity of hunting preservation, maintaining hunting zones where the principle of free access still remains but creating, at the same time, other hunting zones where hunting rights are privatised.

Nowadays the sector of hunting in Portugal is confronted with two contradictory situations. By one side, the number of the hunters is diminishing. From the beginning of the century, the sector lost almost 90.500 hunters. The number of hunters in 2011/2012 is 133.242. The owners of hunting licence are now inferior in around 5.400 than the last year. These hunters pay around 60 euros to get the licence. In the hunting season of 1999/2000 the number of hunters with licence was 223.740. That is, perhaps, a good news in terms of conservation purposes, in the sense that this could be interpreted as a reduction in the venation effort with possible better results in the capacity of regeneration of the species.

But another fact is posing some doubts about the capacity of the sector to get a sustainable use of the resources (note that this sector represents potential revenue of 300 million euros, by year): hunters are getting older. For a universe of around of 287.000 potential hunters, only 1000 have less than twenty years. 109.000 have already more than 61. This reflects the difficulties of refreshing the oldest generations of hunters with new hunters with skills and information on subjects related to the nature conservation and the optimal inter-temporal use of natural resources.

References

[1] Alchian, A. and Demsetz, H. (1973), "The Property Rights Paradigm*", Journal of Economic History*, Vol. 33, Nº 1, pp 16-27.

[2] Barros, H. (1949), *História da Administração Pública em Portugal nos séculos XII-XV,* Tomo VI, Sá da Costa, Lisboa.

[3] Berck, P. (1979), *"*Open Access and Extinction*", Econometrica*, Vol. 47, Nº 4, pp 877-882.

[4] Bishop, R. (1978), *"*Endangered Species and Uncertainty: The Economics of a Safe Minimum

Standard*", American Journal of Agricultural Economics*, Vol.60, Nº 1, pp 10-18.

[5] Bromley, D. (1991), "Testing for Common versus Private Property: Comment*", Journal of Environmental Economics and Management*, Vol. 21, Nº 1, pp 92-96.

[6] Brown, Jr, G. and Goldstein, J. (1984), "A Model for Valuing Endangered Species*", Journal of Environmental Economics and Management*, Vol. 11, Nº 4, pp 303-309.

[7] Buschena, D., Anderson, T. and Leonard, J. (2001), "Valuing Non-Marketed Goods: The Case of Elk Permit Lotteries", *Journal of Environmental Economics and Management,* Vol. 41, pp 33-43.

[8] Carmo, M. (2000), *O Problema da Caça no Alentejo (1901-1975),* Tese de Mestrado, Faculdade de Letras/ Universidade de Lisboa.

[9] Ciriacy-Wantrup, S. (1957), *Conservacion de los Recursos, Economia y Política,* Fondo de Cultura Economica, México.

[10] Clark, C. (1990), *Mathematical Bioeconomics, The Optimal Management of Renewable Resources*, 2nd Edition, Wiley-Interscience Publication, John Wiley and Sons.

[11] Clark, C. and Munro, G. (1975), "The Economics of Fishing and Modern Capital Theory: A Simplified Approach", *Journal of Environmental Economics and Management*, Vol. 2, Nº 2, pp 235-244.

[12] Coelho, M.(2009), "Roman Legal Tradition and the Mismanagement of Hunting Resources"; *Proceedings do 15º Congresso da APDR (Associação Portuguesa de Desenvolvimento Regional), 1º Congresso de Desenvolvimento Regional de Cabo Verde, 2º Congresso Lusófono de Ciência Regional, 3º Congresso de Gestão e Conservação da Natureza*, Cidade da Praia, Cabo Verde.

[13] coelho, M. (2003), "The Economics of Hunting: Roman Law vs German Law", ISEG/UTL, Departamento de Economia, Seminário do Departamento Nº 25/ 2003.

[14] Coelho, M. (2003), "Sobre Comuns e Tragédias – Recursos Naturais e Direitos de Propriedade", *Proceedings do V Encontro de Economistas de Língua Portuguesa*, Recife, www.decon.ufpe.br/veelp

[15] Coelho, M. (1999), *A Tragédia dos Comuns Revisitada, A Pesca do Bacalhau na Terra Nova: Consequências do Regime das 200 Milhas*; ISEG/UTL, Lisboa.

[16] Coelho, M. , Filipe, J. and Ferreira, M. (2010), "On Commons, Anticommons and Tragedies", Romão, Silva E Ferreira (orgs.) *Homenagem ao Professor Doutor Adelino Torres, Colecção Económicas*, Nº 14, II série, pp.587-600.

[17] Conrad, J. (2000), "Wilderness: options to preserve, extract, or develop", *Resource and Energy Economics*, Vol. 22, pp 205-219.

[18] Dasgupta, P. and Heal, G. (1979), *Economic Theory and Exhaustible Resources,* Cambridge University Press.

[19] Demsetz, H. (1967), "Toward a Theory of Property Rights", *American Economic Review,* Vol57, pp 347-359.

[20] Faucheux, S. and Noel, J. (1995); *Economia dos Recursos Naturais e do Meio Ambiente,* Instituto Piaget.

[21] Filipe, J., Coelho, M. E Ferreira, M. (2007), *O Drama dos Recursos Comuns. À procura de soluções para os ecossistemas em perigo,* Edições Sílabo, Lisboa.

[22] Fisher, A., Krutilla, J. (1985), "Economics of Nature Preservation", in Kneese, A. and Sweeney, J. (eds.), *Handbook of Natural Resource and Energy Economics*, Vol. II, North-Holland, Amsterdam.

[23] Fisher, A., Krutilla, J. and Cicchetti, C. (1972), "The Economics of Environmental Preservation: A Theoretical and Empirical Analysis*", American Economic Review*, Vol. 62.

[24] Gordon, H. S. (1954), "The Economic Theory of a Common Property Resource: The Fishery*", Journal of Political Economy*, Vol. 62, pp 124-142.

[25] Hardin, G. (1968), "The Tragedy of the Commons*", Science*, Vol. 162, pp 1243-1247.

[26] Hasenkamp, G. (1995); "The economics of hunting, game-preservation and their legal setting", *European Journal of Political Economy*, Vol. 11, pp 453-468.

[27] IUCN (2001), *The Red List of Threatened Species*, http://www.redlist.org/info

[28] Milon, J. and Clemmons, R. (1991), "Hunter's Demand for Species Variety*", Land Economics*, Vol. 67, Nº 4, pp 401-412.

[29] Munro, G. (1982), "Fisheries, extended jurisdiction and the economics of common property resources*", Canadian Journal of Economics*, Vol. 15, Nº 3, pp 405-425.

[30] Myers, N. (1989), "A Major Extinction Spasm: Predictable and Inevitable?" in Western, D. and Pearl, M (eds.), *Conservation for the Twenty-first Century,* Oxford University Press, pp 42-49.

[31] Naughton-Treves, L. and Sanderson, S. (1995), "Property, Politics and Wildlife Conservation", *World Development*, Vol. 23, Nº 8, pp 1265-1276.

[32] Neher, P. (1974), "Notes on the Volterra - Quadratic Fishery", *Journal of Economic Theory*, Vol. 8, pp 39-49.

[33] Neher, P. (1990), *Natural Resource Economics: Conservation and Exploitation,* Cambridge University Press.

[34] Paulo, A. and Vieira, N. (1988), *Gestão Cinegética*, Direcção Geral das Florestas.

[35] Pearce, D. and Moran, D. (1994), *O Valor Económico da Biodiversidade,* Instituto Piaget.

[36] Pearce, D. and Turner, R. (1990), Economics *of Natural Resources and the Environment*, Harvester Wheatsheaf.

[37] Rosário, L. (1984), *A Fiscalização da Caça em Portugal,* Direcção Geral das Florestas.

[38] Rosário, L. E Barreto, L (S/d), *O Ordenamento Cinegético no Contexto dos Problemas de Ordenamento do Território*, Direcção Geral das Florestas.

[39] Schaefer, M. (1957), "Some Considerations of Population Dynamics and Economics in Relation to the Management of the Commercial Marine Fisheries", *Journal of the Fisheries Research Board of Canada*, Vol. 14, pp 669-681.

[40] Schlager, E. and Ostrom, E. (1992), "Property-Rights Regimes and Natural Resources: A Conceptual Analysis", *Land Economics*, Vol. 68, Nº 3, pp 249-262.

[41] Seabright, P. (1993), "Managing Local Commons: Theoretical Issues in Incentive Design", *Journal of Economic Perspectives*, Vol. 7, Nº 4, pp 113-134.

[42] Smith, R. and Shogren, J. (2002), "Voluntary Incentive for Endangered Species Protection", *Journal of Environmental Economics and Management,* Vol. 43, pp169-187.

[43] Smith, V. L. (1968), "Economics of Production from Natural Resources", *American Economic Review*, Vol. 58, Jun, pp 409-431.

[44] Smith, V. L. (1975), "The Primitive Hunter Culture, Pleistocene Extinction and the Rise of Agriculture*", Journal of Political Economy*, Vol. 83, Aug., pp 727-755.

[45] Tietenberg, T. (2003), *Environmental and Natural Resource Economics*, sixth edition, Addison Wesley Longman, Inc.

[46] Tisdell, C. (1991), *Economics of Environmental Conservation*, Elsevier Science Publishers, Amsterdam.

[47] Weitzman, M. (1974), "Free Access vs. Private Ownership as Alternative Systems for Managing Common Property", *Journal of Economic Theory*, Vol. 8, Nº 2, pp 225-234.

[48] Wilen, J. (1985), "Bioeconomics of Renewable Resource Use", in Kneese, A. and Sweeney, J. (eds.), *Handbook of Natural Resource and Energy Economics*, Vol. I, North-Holland.

[49] Wilson, E. (1989), "Conservation: The Next Hundred Years*"*, in Western, D. and Pearl, M. (eds.), *Conservation for the Twenty-first Century*, Oxford University Press, New York, pp 3-7.

Regulation

[50] Lei de Bases da Caça (Lei Nº 173/99 de 21 de Setembro) , Diário da República- I Série- A, pp. 6532-6541

[51] Decreto-Lei Nº227-B/2000 de 15 de Setembro – Diário da República- I Série-A, pp 4946(2)-4946(31).

Random Walks in the Representation of Reserves

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Abstract— **Models based on Random Walks are presented in this work, to represent reserves. Their main objective is to study and guarantee the sustainability of pensions funds. The use of these models with this goal is a classical approach in the study of pensions funds.**

Keywords — *Random walk, pensions funds, ruin.*

1. Introduction

Gambler's ruin problem, which reserves behave according to a simple random walk, is presented in a lot of text books about the stochastic processes theory in relation with Markov Chains, Random Walks, Martingales and even in other contexts. Very clear approaches to this subject are Billingsley (1986, page 88) and Feller (1968, page 344) that solve the problem through the classic first step analysis in order to obtain a difference equation. This proceeding is followed in this work. In alternative, Grimmett and Stirzaker (1992, page 444) and Karlin and Taylor (1975, page 263) present also resolutions of the problem through the Martingales Theory, as an applications example of the Martingales Stopping Time Theorem.

In the next section the gambler's ruin problem is presented. In the following an approach based on the general random walk, enlarging the former one, is outlined. The work finishes with conclusions and a brief list of references.

2. Gambler's Ruin

So consider a gambler disposing of an initial capital of x euro that intends to play a sequence of games till his/her fortune reaches a value of k euro. Suppose that x and k are integer numbers that satisfy the conditions $x > 0$ and $k > x$. In each game, the gambler either wins 1 euro with probability p or loses 1 euro with probability $q = 1 - p$. Which is the probability that the gambler ruins before attaining his/her target? That is, which is the probability of losing the x euro before accumulating wins in the amount of $k - x$ euro?

Call $X_n, n = 1, 2, ...$ the result of the nth game. Evidently $X_1, X_2, ...$ are independent and identically distributed random variables with probability function:

$$P(X_n = 1) = p, P(X_n = -1) = q = 1 - p.$$

So, the reserves, that is: the fortune, of the player after the nth game correspond to the simple random walk:

$$S_0 = x, S_n = S_{n-1} + X_n, n = 1, 2, ...$$

It is intended to determine the gambler's ruin probability. Call this probability $\rho_k(x)$. It corresponds to the probability that $S_n = 0$ and $0 < S_i < k, i = 0, 1, ..., n - 1$ for $n = 1$ or $n = 2$ or .... If $\rho_k(x)$ is conditioned to the result of the first game it is obtained, as a consequence of the Total Probability Law,

$$\rho_k(x) = p\rho_k(x + 1) + q\rho_k(x - 1),$$
$$0 < x < k \qquad (2.1).$$

Considering conveniently $0 \leq x \leq k$, this difference equation is easy to solve with the support of the evident border conditions

$$\rho_k(0) = 1, \rho_k(k) = 0 \qquad (2.2).$$

Write (2.1) as

$$\rho_k(x) - \rho_k(x - 1) = \frac{p}{q}\big(\rho_k(x + 1) - \rho_k(x)\big),$$
$$0 < x < k \qquad (2.3).$$

For $x = k - 1$ and considering (2.2),

$$\rho_k(k - 2) = \rho_k(k - 1)\left(1 + \frac{p}{q}\right).$$

Based on this equation, when $x = k - 2$, (2.3) becomes:

$$\rho_k(k - 3) = \rho_k(k - 1)\left(1 + \frac{p}{q} + \left(\frac{p}{q}\right)^2\right).$$

Going on with this proceeding it is obtained the general expression

$$\rho_k(k - y) = \rho_k(k - 1)\left(1 + \frac{p}{q} + \left(\frac{p}{q}\right)^2 + \cdots \right.$$
$$\left. + \left(\frac{p}{q}\right)^{y-1}\right), 0 < y \le k \qquad (2.4).$$

Considering again (2.2), after (2.4), with $y = k$ it is obtained

$$\rho_k(k - 1)$$
$$= 1 \Big/ \left(1 + \frac{p}{q} + \left(\frac{p}{q}\right)^2 + \cdots + \left(\frac{p}{q}\right)^{k-1}\right) \qquad (2.5).$$

Finally, substituting (2.5) in (2.4) and performing the change of variable $y = k - x$ it is obtained the solution of the difference equation (2.1) with the border conditions (2.2):

$$\rho_k(k - 1) = \begin{cases} \dfrac{1 - (p/q)^{k-x}}{1 - (p/q)^k}, \text{if } p \ne \dfrac{1}{2} \\[4mm] \dfrac{k - x}{k}, \qquad \text{if } p = \dfrac{1}{2} \end{cases} \qquad (2.6).$$

Call N_a the first passage time by a of the random walk S_n:

$$N_a = \min\{n \ge 0: S_n = a\}.$$

In consequence it is possible to write $\rho_k(x) = P(N_0 < N_k|S_0 = x)$. And it is pertinent to take in (2.6) the limit as k converges to ∞ to evaluate $\rho(x)$, the ruin probability of a gambler infinitely ambitious.

In the context of the simple random walk S_n, $\rho(x) = P(N_0 < \infty|S_0 = x)$. After (2.6)

$$\rho(x) = \lim_{k \to \infty} \rho_k(x) = \begin{cases} (q/p)^x, \text{if } p > \dfrac{1}{2} \\[4mm] 1, \qquad \text{if } p \le \dfrac{1}{2} \end{cases} \qquad (2.7).$$

Note that $\mu = E[X_n] = 2p - 1$. It is relevant to see, after (2.7), that the ruin probability is 1 for the simple random walk at which the mean of the step is $\mu \le 0 \Leftrightarrow p \le \frac{1}{2}$.

3.   The General Random Walk

Suppose that the contributions (pensions) received (paid), by time unit, for a fund may be described as a sequence of random variables $\xi_1, \xi_2, \ldots$ $(\eta_1, \eta_2, \ldots)$. State that $\xi_n(\eta_n)$ is the value of the contributions (pensions) received (paid) by the fund during the nth time unit and so $X_n = \xi_n - \eta_n$ is the reserves variation occurred in the fund at the nth time unit. Supposing that $X_1, X_2, \ldots$ is a sequence of non degenerated random variables, independent and identically distributed, so the stochastic process defined recursively as:

$$\tilde{S}_0 = x, \tilde{S}_n = \tilde{S}_{n-1} + X_n, \qquad \text{with } n = 1, 2, \ldots,$$

is a general random walk that represents the evolution of the fund reserves, since the initial level x till the value $\tilde{S}_n$ after n time units.

It is intended to study the game reserves exhaustion probability, that is the fund ruin. For x and k real numbers fulfilling $x > 0$ and $k > x$, it is considered first the evaluation of $\rho_k(x)$, the probability that the fund reserves decrease from an initial value x to a value in $(-\infty, 0]$ before reaching a value in $[k, +\infty)$. Then, by passing the limit, as in the former section, it is considered the evaluation of $\rho(x)$, the eventual fund ruin probability, admitting so that the random walk, that represents its reserves, evolves with no restrictions at the right of 0.

The method exposed is recognized in the stochastic processes literature as Wald's Approximation. The expositions of Grimmett and Stirzaker (1992, page 407) and Cox and Miller (1965, page 55), about this subject are closely followed in this work. It will be considered   the   process $S_n = \tilde{S}_n - x$, that is, the random walk

$$S_0 = 0, S_n = S_{n-1} + X_n, n = 1, 2, \ldots.$$

instead of the $\tilde{S}_n$ process.

So, when evaluating $\rho_k(x)$, what in fact is being considered is the probability that the process S_n is visiting the set $(-\infty, -x]$ before visiting the set $[k-x, +\infty)$. And when evaluating $\rho(x)$ what is being considered is only the probability that the process S_n goes down from the initial value 0 till a level lesser or equal than $-x$.

Begin considering the non-null value θ for which the X_1 moments generator function assumes the value 1. It is assumed that such a θ exists, that is, θ satisfies

$$E[e^{\theta X_1}] = 1, \theta \neq 0 \qquad (3.1).$$

Define the process:

$$M_n = e^{\theta S_n}, n = 0, 1, 2, \dots.$$

It is obvious that $E[|M_n|] < \infty$ and that, after (3.1)

$$
\begin{aligned}
E[M_{n+1}|X_1, X_2, \dots, X_n] \\
= E[e^{\theta(S_n + X_{n+1})}|X_1, X_2, \dots, X_n] \\
= e^{\theta S_n} E[e^{\theta X_{n+1}}|X_1, X_2, \dots, X_n] \\
= M_n.
\end{aligned}
$$

So, the process M_n is a Martingale in relation to the sequence of random variables $X_1, X_2, \dots$. Consider now N the S_n first passage time to outside the interval $(-x, k-x)$:

$$N = \min\{n \geq 0 : S_n \leq -x \text{ or } S_n \geq k - x\}.$$

It is easy to check that the random variable N is a stopping time – or a Markov time – for which the following conditions are fulfilled:

$$E[N] < \infty \text{ and}$$
$$E[|M_{n+1} - M_n||X_1, X_2, \dots, X_n] \leq 2e^{|\theta|a}, \text{ for } n < N$$

and $a = -x$ or $a = k - x$.

In relation with this subject see Grimmett and Stirzaker (1992, page 467). Under these conditions, it is possible to apply the Martingales Stopping Time Theorem and, in consequence:

$$E[M_n] = E[M_0] = 1 \qquad (3.2).$$

Also

$$
\begin{aligned}
E[M_n] = E[e^{\theta S_N}|S_N \leq -x]P(S_N \leq -x) + \\
E[e^{\theta S_N}|S_N \geq k - x]P(S_N \geq k - x) \ (3.3).
\end{aligned}
$$

Performing the approximations

$$E[e^{\theta S_N}|S_N \leq -x] \cong e^{-\theta x}$$

and

$$E[e^{\theta S_N}|S_N \geq k - x] \cong e^{\theta(k-x)},$$

and considering that $P(S_N \leq -x) = \rho_k(x) = 1 - P(S_N \geq k - x)$, after (3.2) and (3.3), it is obtained

$$\rho_k(x) \cong \frac{1 - e^{\theta(k-x)}}{e^{-\theta x} - e^{\theta(k-x)}}, \text{when } E[X_1] \neq 0 \quad (3.4).$$

This is the Classic Approximation for the Ruin Probability in the conditions stated in (3.1). Note that to admit a non-null solution θ for the equation $E[e^{\theta X_1}] = 1$ implies in fact to assume that $E[X_1] \neq 0$.

Out of these considerations is the situation for which the only solution of the equation $E[e^{\theta X_1}] = 1$ is precisely $\theta = 0$; it means, situation at which $E[X_1] = 0$. This case may be dealt through the following passage to the limit:

$$
\begin{aligned}
\rho_k(x) \cong \lim_{\theta \to 0} \frac{1 - e^{\theta(k-x)}}{e^{-\theta x} - e^{\theta(k-x)}} = \frac{k-x}{k}, \\
\text{when } E[X_1] = 0 \qquad (3.5).
\end{aligned}
$$

As for $\rho(x)$, the probability that the process S_n decreases eventually from the initial value 0 to a level lesser or equal than $-x$, is also got from (3.4), now for a different passage to the limit:

$$
\begin{aligned}
\rho(x) \cong \lim_{k \to \infty} \frac{1 - e^{\theta(k-x)}}{e^{-\theta x} - e^{\theta(k-x)}} = e^{\theta x}, \\
\text{if } \theta < 0 \Leftrightarrow E[X_1] > 0 \qquad (3.6).
\end{aligned}
$$

As it may be deduced from the former section results about the simple random walk, it is legitimate to accept $\rho(x) = 1$ when $\theta \geq 0 \Leftrightarrow E[X_1] \leq 0$.

4.   Example

Suppose that $X_1, X_2, \dots$ constitute a sequence of independent random variables with normal

distribution with mean μ and standard deviation σ. That is, admit that X_n, the fund reserves variation at the nth time unit, has normal distribution with those parameters. In this case, the moments generator function is:

$$E\left[e^{\theta X_1}\right] = \frac{1}{\sqrt{2\pi}\sigma} \int_{-\infty}^{+\infty} e^{\theta x - \frac{(x-\mu)^2}{2\sigma^2}} dx = e^{\theta\mu + \frac{\theta^2\sigma^2}{2}}.$$

The solution of the equation (3.1) is given by

$$\theta = \frac{-2\mu}{\sigma^2}, \mu \neq 0.$$

The ruin probability $\rho_k(x)$ is obtained substituting this result in (3.4):

$$\rho_k(x) \cong \frac{1 - e^{-\frac{2\mu(k-x)}{\sigma^2}}}{e^{\frac{2\mu x}{\sigma^2}} - e^{-\frac{2\mu(k-x)}{\sigma^2}}}, \text{when } \mu \neq 0 \quad (4.1).$$

It is evident that this particularization does not influence the approximation to $\rho_k(x)$ when $\mu = 0$ that, as it was seen, is given by (3.5). After (3.6),

$$\rho(x) \cong e^{-\frac{2\mu x}{\sigma^2}}, \quad \text{when } \mu > 0 \quad (4.2).$$

5. Conclusions

The simple and general random walks are classic stochastic processes broadly studied. They do not appear only as reserves evolution models. Are also used to build more complex systems and as analysis instruments, in a theoretical feature, of other kind of systems.

In the approach presented some methodologies applied in the study of this kind of processes are highlighted: Difference Equations and Martingales Theory.

It is important to note that, with this approach the reserves systems are treated as if they were physical systems. It is not obvious that the direct application of these principles to financial reserves funds, ignoring their own valuation and devaluation dynamics as time goes by, is legitimate.

Those models, and the consequent stability systems appreciation done with basis on the evaluation of the probability of the reserves exhaustion or ruin, seem valid only in scenarios where constant prices are considered. The integration of factors associated to the time depreciation process of the value of the money in the modulation of financial reserves, although complicating eventually the mathematical models involved, seems important.

Acknowledgments

References

[1] Andrade, M. (2010), *"A Note on Foundations of Probability"*, Journal of Mathematics and Technology, Vol 1, No 1, pp. 96-98.

[2] Billingsley, P. (1986), *"Probability and Measure"*, 2nd Ed. John Wiley & Sons, New York.

[3] Cox, D. R. and Miller, H. D. (1965), *"The Theory of Stochastic Processes"*, Chapman & Hall, London.

[4] Feller, W. (1968), *"An Introduction to Probability Theory and its Applications"*, Vol 1, 3rd Ed. John Wiley & Sons, New York.

[5] Ferreira, M. A. M. (2010), *"A Note on Jackson Networks Sojourn Times"*, Journal of Mathematics and Technology, Vol 1, No 1, pp. 91-95.

[6] Ferreira, M. A. M. and Andrade, M. (2011), *"An Infinite Servers Nodes Network in the Study of a Pensions Fund"*, International Journal of Latest Trends in Finance and Economic Sciences, 1(2), 91-94.

[7] Figueira, J. (2003), *"Aplicação dos Processos de Difusão e da Teoria do Renovamento num Estudo de Reservas Aleatórias"*, PhD Thesis, ISCTE.

[8] Figueira, J. and Ferreira, M. A. M. (1999), *"Representation of a Pensions Fund by a Stochastic Network with Two Nodes: an Exercise"*, Portuguese Review of Financial Markets, Vol 2, No 1, pp. 75-81.

[9] Grimmett, G. R. and Stirzaker, D. R. (1992), *"Probability and Random Processes"*, 2nd Ed. Clarendon Press, Oxford.

[10] Karlin, S. and Taylor, H. M. (1975), *"A First Course in Stochastic Processes"*, 2nd Ed. Academic Press, New York.

The Impact of Corporate Rebranding on the Firm's Market Value

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Abstract *- **Rebranding corresponds to the creation of a new name, term, symbol, design or a combination of them for an established brand with the intention of developing a differentiated position in the mind of stakeholders and competitors. Increased competition has led firms to an avenue of differentiation, and rebranding has been approached by firms in order to differentiate themselves and to promote the corporate image. Corporate rebranding, although commonly referred in the press, has received little attention from academia. This paper tends to contribute to fill this gap in the academic literature, by analysing the impact that corporate image through rebranding has on the firms' stock market value, using event study methodologies. We focus on firms listed on the Lisbon Stock Market in the period 2000 – February 2009. We do not find evidence of a positive impact of corporate rebranding on firm value, in Portuguese firms. In fact, our results suggest that these events may have a negative impact on firm value, even though our empirical evidence is weak, in supporting this conclusion.***

***Keywords** - corporate image, rebranding, market value, event study*

1. Introduction

Increasing global competition has led firms toward an even higher need for distinctiveness. When looking at the variables that are most qualified to sustain a competitive advantage, the corporate image emerges (Kay, 2006). Adopting the definition proposed by Muzellec and Lambkin (2006), rebranding corresponds to the creation of a new brand element aiming to create a new image or position in the mind of stakeholders. A good and strong corporate image can have a positive impact on workers, managers, investors, and customers' evaluations. On the other hand, rebranding is a strategy involving considerable risks, as strong brands take years to be successfully built in order to provide higher margins, loyal customer bases and a continuous stream of income for the firm representing the brand (Aaker, 1996; Keller, 2002).

As corporate rebranding decisions aim to add value to the firm, by sending a positive sign to stakeholders, the success and economical rationale of these decisions may be judged by identifying its impact on firm value, i.e., the impact on the firm's stock price. In fact, the market value of a firm's traded securities reflects an unbiased estimate of future cash flows (Simon and Sullivan, 1993). A corporate rebranding signals the market that something in the firm has changed, hopefully implying a more positive outlook.

In evaluating the impact of these types of events, we use event study methodologies, which have been previously applied extensively in different fields of economic, finance and management studies. Under the assumption that markets are efficient, the impact of corporate branding decisions on stock prices should occur on the day of the announcement, or in the next day, if the market is already closed when the news is disclosed. Therefore, event study methodologies try to detect abnormal returns in stock prices on and around the event day. Evidence of the effect that corporate rebranding decisions have on firm value is relevant both for the firm's managers and for investors.

In this paper, we apply event study methodology to Portuguese firms, to analyze the impact of corporate rebranding on their market value, thus adding both to the empirical evidence on this type of event and to the understanding on smaller capital markets. To the best of our knowledge, there are no previous studies covering the impact of rebranding actions in the Portuguese stock market.

The remainder of the paper is organised as follows. In section 2, we present some of the more relevant previous studies on corporate rebranding, including studies that analyse empirically its impact on firm value. Section 3 presents the data and section 4 presents the event study methodologies and statistical tests applied to the data. In section 5 we present the empirical results. Finally, in section 6, we present the conclusions.

2. Literature Review

2.1. Corporate Rebranding

A brand is usually defined as 'a name, term, symbol, design or a combination of them intended to identify goods or services of one seller or group of sellers and to differentiate them from those of competitors' (Kotler, 2008). Brands are increasingly viewed as one of the major assets firms possess. Tadelis (1999) defined a firm's reputation (and its associated name) as a valuable intangible asset. Brands differentiate, protect and convey meaning to what firms communicate to customers. Competition increases the

power of brands, as these allow non-price differentiation (Aaker, 1991). Brand names are somewhat different than corporate brand names and corporate brands are more than just trade names (see Muzellec, 2006 for a review on the subject). Following Einwiller and Will (2002, p.101), corporate branding is considered a 'systematically planned and implemented process of creating and maintaining a favourable image and consequently a favourable reputation of the firm as a whole by sending signals to all stakeholders by managing behaviour, communication and symbolism'. Kay (2006) adds that corporate branding is the way an organization communicates its identity. As product brands, corporate brands are designed to evoke positive associations from stakeholders (Dacin and Brown, 2002). Corporate brands are said to be more central and strategic, controlled by top management (Hatch and Schultz, 2003), more abstract, representing higher-order values (de Chernatony, 2002) and more complex, with possible different meanings for different stakeholders (Balmer and Greyser, 2002), when compared to product brands.

The issue of corporate branding has been adequately discussed in the literature, but corporate rebranding has been somehow neglected from academic research, despite firms' evidence of such moves. Most of the existing research on corporate rebranding focuses on revolutionary rebranding, such as the creation of a new name (Horsky and Swyngedouw, 1987; Delattre, 2002; Muzellec and Lambkin, 2006; Muzellec, 2006). In this paper, we approach all the continuum of rebranding, trying to include minor and major changes to corporate branding.

A good and strong corporate image influences current workers (Riordan et al., 1997), investors (Fombrun and Shanley, 1990), future applicants (Dowling, 1988) and customers' evaluations and preferences (Bravo et al., 2009; Howcroft, 1991). That is to say that managing a strong corporate brand is different than managing strong product brands: corporate brands are communicated to different stakeholders and may have lesser impact on consumers (Kay, 2006). A well conceived, solid, strong corporate branding strategy provides management with a holistic framework to integrate the firm's activities, its vision and mission; it allows the firm to express its distinctiveness, that is, to differentiate itself in the relationship with stakeholders (Schultz and de Chernatony, 2002), and represents an opportunity to increase the future incomes of the firm.

Sometimes, despite the high budgets spent on communicating the corporate positioning, firms fail to create a distinctive image and have to rebrand (Bravo et al., 2009). The reasons to rebrand can come from changing external conditions, weaker competitive position, changing ownerships structures and/or changes in corporate strategy (Fombrun and Shanley, 1990; Muzellec and Lambkin, 2006). Delattre (2002) finds four categories of reasons to rebrand: new corporate image, new management or shareholding structure, new activity, and change of legal status. Despite the

motivation and the investment involved, rebranding has its risks: part of existing accumulated goodwill, in the form of name recognition, corporate image, and routinized purchase behaviour, can be lost (Horsky and Swyngedouw, 1987).

Hence, corporate rebranding can be distinguished from corporate branding as the former refers to a change between an initially formulated corporate brand and a new formulation (Merrilees and Miller, 2008). Muzellec and Lambkin (2006) define rebranding as the creation of a new name, term, symbol or design for an established brand, in order to create a differentiation in the mind of stakeholders and competitors. As a brand is composed of tangible and intangible elements, rebranding may consist of changing one or all of these elements along a continuum (Daly and Moloney, 2004): from minor improvements to the visual identity of the corporate brand (i.e., logos and slogans) defining an evolutionary rebranding, to major changes such as the creation of a new name, i.e. revolutionary rebranding (Daly and Moloney, 2004; Muzellec and Lambkin, 2006). Delattre (2002) divides corporate name changes into 'level 1' changes (when reorganising the elements of a whole system that remains unchanged) and 'level 2' changes (when the system is modified). We can consider these two levels as similar to the evolutionary/revolutionary continuum.

Rebranding strategies are directly linked with brand equity management. Firms wanting to add value to their offer through corporate rebranding have to evaluate and manage their brand equity. One approach to assess the value of brand equity derives from finance theory and uses the stock price as the evaluation basis (Aaker, 1991). The argument is that the stock market will adjust the price of a firm to reflect future prospects of its brands. Stakeholders' define their image of the firm based on the signals that emanate from it. Corporate rebranding is a very strong formal signal that stakeholders receive that something about the corporation has changed (Muzellec and Lambkin, 2006). It is expected that these corporate rebranding actions will impact the corporate market value and thus constitute a signal that shareholders will use when they evaluate the firm. One mentioned disadvantage of working with the stock market relates to the need of events to be sufficiently large to be detected. Corporate rebranding exercises are considered major events and so noticeable.

2.2. From Corporate Rebranding to Market value

This financial market perspective derives from the 'efficient markets' literature, that forecasts that in a well-functioning capital market, stock prices are the best available unbiased estimates of the value of the assets of a firm (Simon and Sullivan, 1993; Fama, 1970). It is preferable to use the financial market valuation than historic accounting measures that fail to incorporate the expected future returns of rebranding actions. Additionally, by using objective market based measures, comparisons over time and industries are possible. Dowling (2006) presents a framework linking corporate

reputation to the creation of shareholder value, based on the four-part valuation model of Copeland, Koller and Murrin (2000). He claims that a good corporate reputation will be a part of the firm's intrinsic value which will be factored into the firm's share price. Einwiller and Will (2002) find evidence that a strong corporate brand and a favourable reputation contribute to higher stock prices. Successful corporate branding strategies will provide an opportunity for generating a significant future income stream (Schultz and de Chernatony, 2002), which, under the hypothesis of efficient markets, will be reflected on the stock price.

A common approach to analyse this financial market perspective, i.e., the impact of corporate rebranding in market value, is provided by event study methodology. In marketing, event studies have been published across research streams linked to product, promotion and services (see Johnston (2007) for a metanalysis on the subject). Under the promotion research area, corporate name changes have been analysed by several researchers including Howe (1982), Horsky and Swyngedouw (1987), Bosch and Hirschey (1989), Simon and Sullivan (1993), Karpoff and Rankine (1994), Karbhari, Sori and Mohamad (2004), Kilic and Dursun (2006). Most of these studies find a non significant market reaction as a consequence of a corporate name change. One possible reason presented by Karpoff and Rankine (1994) is that those changes are anticipated by the market. However, Kilic and Dursun (2006) conclude that a name change has a positive impact on the firm's value. Horsky and Swyngedouw (1987) claim that name changes signal to the market that measures to improve the performance will be adopted by the firm, which can contribute to a positive impact on shareholders' value.

3. Data

In this paper, we aim to study the impact on firm value of corporate rebranding events, of Portuguese firms quoted in the Lisbon Stock Exchange (Euronext Lisbon). To that purpose, we consider all the rebranding events that occurred in the period from January 2000 to April 2010. The identification of the event dates results from an extensive research on the media and corresponds to the day of the public announcement of the corporate rebranding campaign. After controlling for confounding effects (contemporary events), such as dividend distribution announcements and capital increases, and for the lack of liquidity, we end up with a sample of 17 observations.

4. Methodology

The method chosen to analyse the impact of corporate rebranding on market value is event study methodology. This method measures the stock price reaction to the unanticipated announcement of an event. In our case, the event is the announcement of a corporate rebranding action. The event study methodology is based on the hypothesis of efficient

markets (Fama, 1970). If stock prices reflect all the available information of firms, then when the market faces an event that is not anticipated, abnormal returns should happen with a positive or negative impact on stock prices. An appropriate event is an event likely to have a financial impact on the firm, providing new information that is unanticipated by the market and where there are no confounding effects (McWilliams and Siegel, 1997).

We define the event day as the day when the new corporate brand is announced in the media. In a fully efficient market, we would expect that the impact on stock prices occurs either on the event day (day 0) or in the following day (day +1), if the information only became available after the market closing of the event day. In practice, it is normal to consider a larger set of days around the event window. We define the event window including days -5 to +5, relative to the event day. This allows for the possibility that the arrival of information to the market, about the corporate rebranding, has been leaked before the event day, which could lead to an effect on price occurring on the days before day 0. Also, allowing for the possibility of some market rigidities, or a lagged response by investors, we analyze price behaviour until day +5.

It is important to note that the broadening of the event window to include more days has the disadvantage that prices, in that period, might be affected by confounding effects, including other significant announcements about the firm. Therefore, it is important to use an event window as narrow as possible, balancing the pros and cons of smaller and larger windows. As the event window of [-5; +5] is arbitrarily chosen, we also observe the behaviour of returns in two smaller windows [-2;+2] and [+1,+3], to confirm the robustness of our results.

The appraisal of the event's impact requires measuring abnormal returns around the event day. The abnormal return is the return of the stock during the event window, deducted by the normal return of the firm, over the same period. The normal return is defined as the expected return if the event did not take place. Following MacKinlay (1997), we define for firm i and event date t, the abnormal return as:

$$AR_{it} = R_{it} - E(R_{it} \mid X_t) \qquad (1)$$

where AR_{it}, R_{it} and $E(R_{it} \mid X_t)$ are the abnormal, actual and normal returns respectively for firm i in time period t. X_t is the conditioning information for the normal return model. We take the common approach of defining X_t as the market return, and thus we estimate the market model for each firm as:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \qquad (2)$$

where R_{it} is the log return on the share price of firm i on day t, R_{mt} is the log return on the PSI 20 stock market index on day t, α_i is the intercept term, β_i is the systematic risk of stock i, and ε_{it} is the error term with $E(\varepsilon_{it}) = 0$.

From estimation of the above equation, we estimate the daily abnormal returns for the ith firm using the following equation:

$$AR_{it} = R_{it} - (a_i + \beta_i R_{mt}) \quad (3)$$

where a_i and β_i are the ordinary least squares (OLS) parameter estimates obtained from the regression of R_{it} on R_{mt} over an estimation period preceding the event, including returns from the estimation window [-150;-30]. The abnormal returns thus represent returns earned by the firm after adjustment for the "normal" expected return, which is determined by the market model. It is, therefore, the disturbance term of the market model calculated on the estimation window.

Given the market model parameter estimates, we can measure and analyze the abnormal returns. Under the null hypothesis (no abnormal returns on the event window), conditional on the event window market returns, the abnormal returns will be jointly normally distributed with a zero conditional mean and conditional variance given by:

$$\sigma^2(AR_{it}) = \sigma_{\varepsilon_i}^2 + \frac{1}{L}\left[1 + \frac{(R_{mt} - \hat{\mu}_m)}{\hat{\sigma}_m^2}\right] \quad (4)$$

where $\sigma_{\varepsilon_i}^2$ is the disturbance variance from (2), L is the number of daily returns in the estimation window, $\hat{\mu}_m$ is the average market return in the estimation window of firm i, and σ_m^2 is the variance of market returns in the same period. We have:

$$\hat{\sigma}_{\varepsilon_i}^2 = \frac{1}{L-2} \sum_{t=-150}^{-30} (R_{it} - a_i - b_i R_{mt})^2 \quad (5)$$

$$\hat{\mu}_m = \frac{1}{L} \sum_{t=-150}^{-30} R_{mt} \quad (6)$$

The second component of (4) is additional variance due to the sampling error in α_i and β_i. Given that L=120 is sufficiently large, the second term is very close to zero, and so we take the approximation that the variance of the abnormal return will be $\sigma_{\varepsilon_i}^2$, and the

abnormal return observations will become independent through time, as suggested by MacKinlay (1997).

Under the null hypothesis, H0, that the corporate rebranding event has no impact on the behaviour of returns (mean or variance), the distributional properties of the abnormal returns can be used to draw inferences over any period within the event window. Under the null hypothesis, the distribution of the sample abnormal return of a given observation in the event window is:

$$AR_{it} \sim N(0, \sigma^2(AR_{it})) \quad (7)$$

The next step is the aggregation of the abnormal returns with the purpose of drawing overall inferences for the event window. The aggregation is performed through time (days in the event window) for each firm, and across firms. We define $CAR(-5,+5)$ as the cumulative abnormal return in the event window, i.e., from day -5 to day +5, and is computed as the sum of the included abnormal returns for firm i:

$$CAR_i(-5,+5) = \sum_{t=-5}^{+5} AR_{it} \quad (8)$$

Asymptotically (as L increases) the variance of CARi approximates

$$\sigma_i^2(-5,+5) = 11.\sigma_{\varepsilon_i}^2 \quad (9)$$

and so, the distribution of the cumulative abnormal return under H0 is

$$CAR_i(-5,+5) \sim N(0, 11.\sigma_{\varepsilon_i}^2) \quad (10)$$

The final step involves aggregation across firms. For this aggregation, we assume that there is no overlapping of the event windows of the included securities, which implies that the abnormal returns and the cumulative abnormal returns will be independent across securities. Assuming independence, we aggregate through firms computing

$$\overline{CAR}(-5,+5) = \frac{1}{N} \sum_{i=1}^{17} CAR_i(-5,+5) \quad (11)$$

and

$$var(\overline{CAR}(-5,+5)) = \frac{1}{N^2} \sum_{i=1}^{17} \sigma_i^2(-5,+5) \quad (12)$$

Inferences about the cumulative abnormal returns can be drawn using

$$\overline{CAR}(-5,+5) \sim N[0, var(\overline{CAR}(-5,+5))] \quad (13)$$

to test the null hypothesis that the abnormal returns are zero. Given that $\sigma_{\varepsilon_i}^2$ is unknown, we use the sample variance measure of $\sigma_{\varepsilon_i}^2$ from the market model

regression in the estimation window. Therefore, H0 can be tested using

$$\theta = \frac{\overline{CAR}(-5,+5)}{\text{var}\left(\overline{CAR}(-5,+5)\right)} \sim N(0,1) \tag{14}$$

which is asymptotic with respect to the number of securities N and to the length of the estimation window L.

Alternatively, the individual securities' abnormal returns can be aggregated by t-day, using the ARit from (3),

$$\overline{AR_t} = \frac{1}{N} \sum_{i=1}^{17} AR_{it} \tag{15}$$

with variance,

$$\text{var}\left(\overline{AR_t}\right) = \frac{1}{N^2} \sum_{i=1}^{17} \sigma_{\varepsilon_i}^2 \tag{16}$$

which we will use to analyze the abnormal returns in each of the t-days in the event window.

5. Results

Figure 1 and 2 depict the development of the average abnormal returns and cumulative average abnormal returns during the event window [-5, +5], respectively. We observe negative abnormal returns in days -5 and -4, followed by positive abnormal returns in days -3 to 0 and again, a decline in returns in the three days following the event, +1, +2 and +3. The cumulative average abnormal return in the 11 days included in the event window is positive, 0.412%.
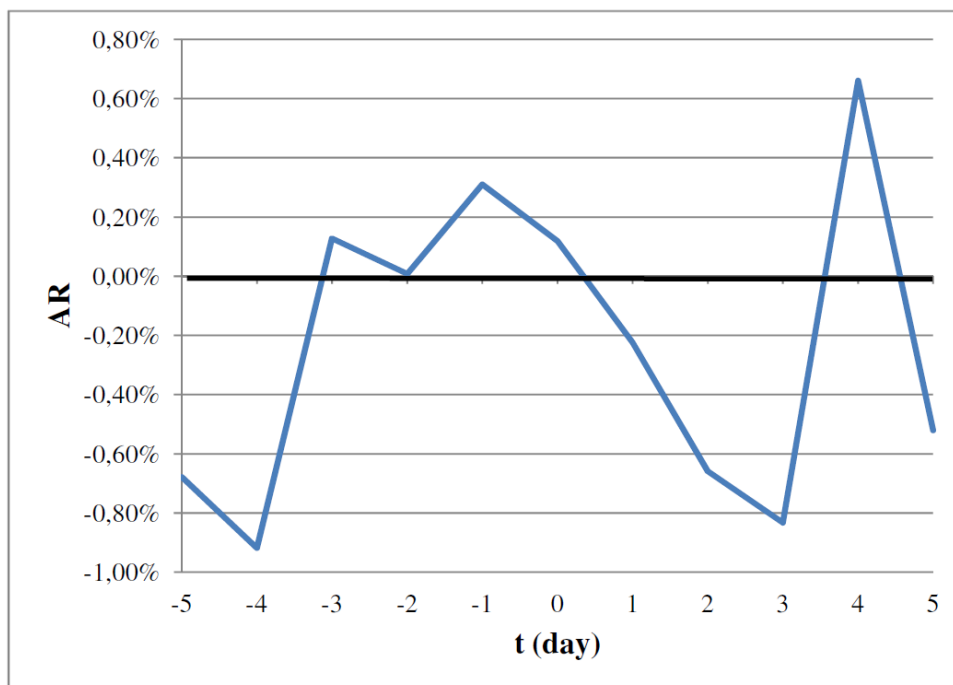

Figure 1 - Sample Average Abnormal Returns

Notes: This figure shows the average abnormal return (AR) for the overall sample of 17 corporate rebranding announcements within the event window of 11 days. Day 0 is the day when the announcement of corporate rebranding was disclosed in the media.

Figure 2 - Sample Cumulative Average Abnormal Returns

Notes: This figure shows the cumulative average abnormal return (CAR) for the overall sample of 17 corporate rebranding announcements within the event window of 11 days. Day 0 is the day when the annou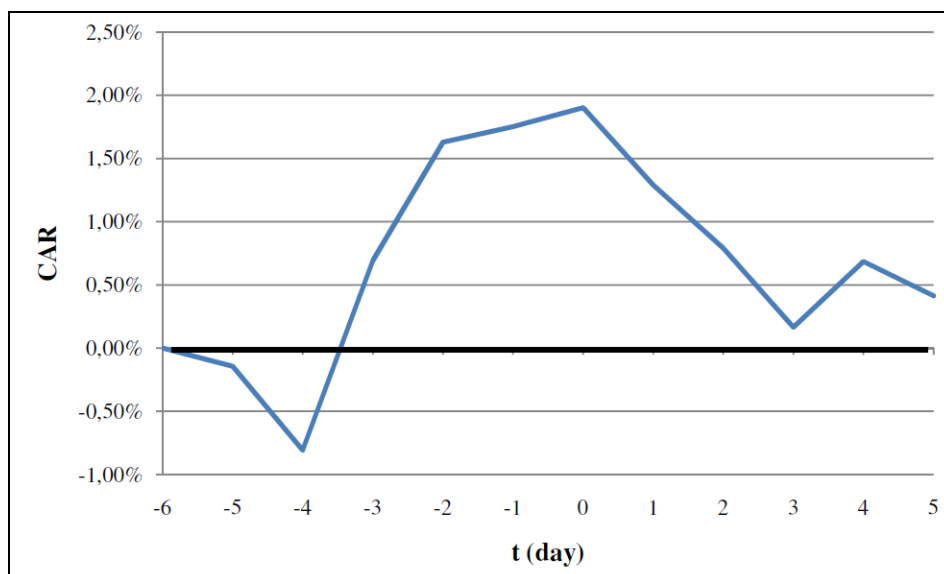ncement of corporate rebranding was disclosed in the media. The cumulative average abnormal return in [-5, +5] is positive, 0.412%.

In our statistical tests, we examine both in cumulative terms and individually, the abnormal returns in the 11 days included in the event window. For robustness, we also test a smaller window, [-2,+2], and given the observation of a negative impact on firm value on days +1, +2 and +3, we also study the aggregated results for these three days. These smaller event windows are more in line with the efficient market hypothesis, which implies that the stock price adjustment should occur very close to day 0. The event window [+1, +3] is consistent with the presumption that there are no leakages of information prior to the announcement in the media, and that there are some rigidities in the market, implying that the adjustment of the stock price to the news does not occur entirely on days 0 and +1, but also on days +2 and +3.

Table 1 presents the results of our parametric tests, on the abnormal returns in each of the 11 days under study, and also for cumulative abnormal returns in event windows [-5,+5], [-2,+2] and [+1,+3]

Table 1 - Sample Parametric Tests

t (day)	# of Observ	Parametric Test		
		Average AR	CAR	p-value (2-tailed)
-5	17	-0.145%	-0.145%	0.822
-4	17	-0.663%	-0.809%	0.304
-3	17	1.501%	0.693%	0.020 *
-2	17	0.936%	1.629%	0.147
-1	17	0.123%	1.752%	0.849
0	17	0.150%	1.901%	0.816
1	17	-0.610%	1.291%	0.344
2	17	-0.499%	0.792%	0.439
3	17	-0.626%	0.166%	0.331
4	17	0.518%	0.684%	0.422
5	17	-0.272%	0.412%	0.674
[-5,+5]	187		0.412%	0.847
[-2,+2]	85		0.099%	0.945
[+1,+3]	51		-1.736%	0.120

Notes: Daily average abnormal returns (AR) and cumulative average abnormal returns (CAR) for all the days in the event window, aggregated across the 17 firms. The p-values test if the average AR in each of the days of the event window [-5,+5] are different from zero. In the bottom lines of the table, we present CAR for three alternative event windows, [-5,+5], [-2,+2] and [+1,+3], and the respective p-values.

* Null hypothesis rejection significant at the 5% level. ** Null hypothesis rejection significant at the 1% level.

The table shows that the cumulative average abnormal returns in the event window [-5,+5] is positive, 0.412%, but not statistically different from zero. In the smaller event window [-2,+2], cumulative abnormal returns are very close to zero. The strongest positive average abnormal return is found on t=-3, which is significant at the 5% level. The null hypothesis is not rejected in any of the remaining days included in the event window. The global results for the window [+1,+3] are also not statistically different from zero.

There are no abnormal returns in windows [-5, +5] and [-2,+2], but the negative CAR in window [+1,+3] is significant at the 5% level.

Overall, our results do not allow rejecting the null hypothesis of no abnormal returns in the event window, and particularly, there is no evidence that the announcement of corporate rebranding has an immediate positive impact on firm value.

6. Conclusions

The event study methodology is a valuable approach to better understand and evaluate the performance of marketing strategies. This methodology, as Hozier and Schatzberg (2000) argue, contributes to solving the problem of integrating firm-level financial data with strategic marketing variables.

Our results are consistent with previous studies (Howe, 1982, Bosch and Hirsche, 1989, Karpoff and Rankine, 1994), which do not find evidence of a significant positive impact on firm value, resulting from corporate rebranding decisions. In our study, not only we do not find such a positive impact, but the evidence from the days after the event (weakly) points in the opposite direction, i.e., corporate rebranding strategies seem to be unfavourably viewed by investors. However, we do not find our results as necessarily implying this conclusion, as there are alternative explanations. Firstly, it is possible that the information on corporate rebranding decisions is frequently leaked to the market well before the official announcement, so that the impact on stock price may occur prior to day -5. Secondly, some studies have found that the Portuguese market has been less than fully efficient in the period under study (Borges, 2011), so it is possible that the "good" or "bad" news implicit in the corporate rebranding are not immediately incorporated in the stock price, nor in the five days following the event.

The main limitation of our study is that we were able to identify only 17 events in the Portuguese market, in the period under study, which is a consequence of a narrow number of quoted firms in the Lisbon stock market, and may also reflect the postponing of rebranding decisions by firms, in the context of sluggish economic growth experienced by Portugal over the last decade. Nevertheless, the size of our sample is similar to other studies (Hozier and Schatzberg, 2000; Pruitt et al., 2004).

References

[1] Aaker, D., *Managing Brand Equity*, Free Press, New York, NY, 1991.

[2] Aaker, D., "*Resisting Temptations to Change a Brand Position/Execution: The Power of Consistency Over time*", Journal of Brand Management, Vol. 3 No. 4, pp.251-258, 1996.

[3] Balmer, J. and Greyser, S., "*Managing the Multiple Identities of the Corporation*", California Management Review, Vol. 44 No. 3, pp.76-86, 2002.

[4] Borges, M., "*Random Walk Tests for the Lisbon Stock Market*", Applied Economics, 43, (4-6), 631-639, 2011.

[5] Bosch, J. and Hirschey, M., "*The Valuation Effects of Corporate Name Changes*", Financial Management, Vol. 18 No. 4, pp.64-73, 1989.

[6] Bravo, R., Montaner, T. and Pina, J., "*Corporate Brand Image in Retail Banking: Development and Validation of a Scale*", The Service Industries Journal, DOI: 10.1080/02642060802311260, 2009

[7] Copeland, T., Koller, T. and Murrin, J., *Valuation: Measuring and Managing the Value of Companies*, John Wiley & Sons, New York, NY, 2000.

[8] Dacin, P. and Brown, T., "*Corporate Identity and Corporate Associations: A Framework for Future Research*", Corporate Reputation Review, Vol. 5 No. 2/3, pp.254-263, 2002.

[9] Daly, A. and Moloney, D., "*Managing Corporate Rebranding*", Irish Marketing Review, Vol. 17 No. 1/2, pp.30-36, 2004.

[10] de Chernatony, L., "*Would a Brand Smell Any Sweeter by a Corporate Name?*", Corporate Reputation Review, Vol. 5 No. 2/3, pp.114-132, 2002.

[11] Delattre, E., "*Business Name Changes: The French Experience*", Journal of Small Business Management, Vol. 40 No. 4, pp.360-367, 2002.

[12] Dowling, G., "*Measuring Corporate Images: A Review of Alternative Approaches*", Journal of Business Research, Vol. 17 No. 1, pp.27-34, 1988.

[13] Dowling, G., "*How Good Corporate Reputations Create Corporate Value*", Corporate Reputation Review, Vol. 9 No. 2, pp.134-143, 2006.

[14] Einwiller, S. and Will, M., "*Towards an Integrated Approach to Corporate Branding – An Empirical Study*", Corporate Communications, Vol. 7 No. 2, pp.100-109, 2002.

[15] Fama, E., "*Efficient Capital Markets: A Review of Theory and Empirical Work*", Journal of Finance, Vol. 25, pp.383-417, 1970.

[16] Fombrun, C. and Shanley, M., "*What's in a Name? Reputation Building and Corporate Strategy*",

Academy of Management Journal, Vol. 33 No. 2, pp.233-258, 1990.

[17] Hatch, M. and Schultz, M.,"*Bringing the Corporation into Corporate Branding*", European Journal of Marketing, Vol. 37 No. 7/8, pp.1041-1064, 2003.

[18] Horsky, D. and Swyngedouw, P., "*Does It Pay to Change Your Company's Name? A Stock Market Perspective*", Marketing Science, Vol. 6 No. 4, pp. 320-335, 1987.

[19] Howcroft, J., "*Customer Satisfaction in Retail Banking*", The Services Industries Journal, Vol. 11 No. 1, pp.11-17, 1991.

[20] Howe, J., "*A Rose by Any Other Name? A Note on Corporate Name Changes*", Financial Review, Vol. 17 No. 4, pp.271-278, 1982.

[21] Hozier, G. and Schatzberg, D., "*Advertising Agency Terminations and Reviews: Stock Returns and Firm Performance*", Journal of Business Research, Vol. 50 No. 2, pp.169-176, 2000.

[22] Jerrel, G. and Peltzman, S., "*The Impact of Product Recalls on the Wealth of Sellers*", Journal of Political Economy, Vol. 93 No. June, pp.512-536, 1985.

[23] Johnston, M., "*A Review of the Application of Event Studies in Marketing*", Academy of Marketing Science Review, Vol. 11 No. 4, pp. 1-31, 2007.

[24] Karbhari, Y., Sori, Z. and Mohamad, S., "*Shareholder Wealth Effects and Corporate Name Changes: Evidence from Malaysia*", Corporate Ownership & Control, Vol. 2 No. 1, pp. 38-49, 2004.

[25] Karpoff, J. and Rankine, G., "*In Search of a Signaling Effect: The Wealth Effects of Corporate Name Changes*", Journal of Banking and Finance, Vol. 18 No. 6, pp.1027-1045, 1994.

[26] Kay, M., "*Strong Brands and Corporate Brands*", European Journal of Marketing, Vol. 40 No. 7/8, pp.742-760, 2006.

[27] Keller, K., *Branding and Brand Equity*, Marketing Science Institute, Cambridge, MA, 2002.

[28] Kilic, C. and Dursun, T., "*The Effect of Corporate Identity Changes on Firm Value: An Empirical Investigation*", Journal of the American Academy of Business, Vol. 10 No. 1, pp.234-240, 2006.

[29] Kotler, P. and Keller, K., *Marketing Management* (13th Ed.), Prentice-Hall, Upper Saddle River, NJ, 2008.

[30] MacKinlay, A., "*Event Studies in Economics and Finance*", Journal of Economic Literature, Vol. 35, pp.13-39, 1997.

[31] Merrilees, B. and Miller, D., "*Principles of Corporate Rebranding*", European Journal of Marketing, Vol. 42 No. 5/6, pp.537-552, 2008.

[32] Muzellec, L., "*What is a Name Change? Re-Joicing Corporate Names to Create Corporate Brands*", Corporate Reputation Review, Vol. 8 No. 4, pp.305-321, 2006.

[33] Muzellec, L. and Lambkin, M., "*Corporate Rebranding: Destroying, Transferring or Creating Brand Equity?*", European Journal of Marketing, Vol. 40 No. 7/8, pp.803-824, 2006.

[34] Pruitt, S., Cornwell, T. and Clark, J., "*The NASCAR Phenomenon: Auto Racing Sponsorships and Shareholder Wealth*", Journal of Advertising Research, Vol. 44 No. 3, 281-296, 2004.

[35] Riordan, C., Gatewood, R. and Bill, J., "*Corporate Image: Employee Reactions and Implications for Managing Corporate Social Performance*", Journal of Business Ethic*s*, Vol. 16 No. 4, pp.401-412, 1997.

[36] Schultz, M. and de Chernatony, L., "*The Challenges of Corporate Branding*", Corporate Reputation Review, Vol. 5 No. 2/3, pp.105-112, 2002.

[37] Simon, C. and Sullivan, M., "*The Measurement and Determinants of Brand Equity: A Financial Approach*", Marketing Science, Vol. 12 No. 1, pp.28-52, 1993.

[38] Tadelis, S., "*What's in a Name? Reputation as a Tradeable Asset*", American Economic Review, Vol. 89 No. 3, pp.548-563, 1999.

Neuromarketing: Consumers and the Anchoring Effect

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Abstract - **The model of economic analysis used on the market by companies has shown too much inability to the explanation of problems arising from the economic man's decision. So that alternative theories have been developed by a conventional series of renowned scientists and institutions. The need of an alternative has generated several different approaches. It is the case of the analysis of behavioral economics, represented in this study by neuromarketing. Theoretical view in the study of the anchoring effect of prices in the consumer's mind is presented. This study evidences the existence of the anchoring effect of prices in consumer decision of students from business courses of the city of Belém – PA (Brazil).**

Keywords— *Consumer, Anchoring, Behavioral Economics, Neuroeconomics, Limited Rationality.*

1. Introduction

In the last decades, reality has allowed remarkable research in terms of the development of scientific and managerial marketing activities. Though, marketing research has been often made very especially in industrialized countries, where it has been possible to make funds available for research development in this area. The future of marketing science is now in a new frontier to internalize new concepts and new developments. High level investments are now required to develop new empirical and experimental/laboratories' research, involving high technology. Anyway, as a result of the new global geostrategic environment for business, the so-called emerging markets also begin to develop strong strategies for research and investigation, domestically. It is the case of India, China or Brazil, for example, where many advances in science are now being developed and important research centers being developed. A new world was born.

Considering the new economic global crisis, companies and governments try to fix up now a plausible explanation for the deleterious events. They are looking for a way to protect goods and the ability to generate wealth. However this search has seemed a vain effort, which is tried by companies and governments when explaining these phenomena. Allied to the multiplication of the mistrust among the economic agents on the market, this reality gets worse as soon as the present hard times get evident in many of the first world countries.

The globalization of the markets is a very important challenge for organizations. It is a reality and many factors are contributing for business at a global scale, as it is the case of worldwide investment, the production and marketing made across frontiers, the weakness of national boundaries relating to the movements of capital, goods and people, the development of some regional unions and regional alliances, the advances in telecommunication technologies and internet, or the world travel facilities, for example. Companies and organizations in general cannot take no notice of this movement toward globalization and companies must be aware of it. Any organization which chooses to be kept out of this trend will face the competition in a global basis anyway because competition comes to the organization's 'front door', either from local, national or international companies. The importance of globalization for marketing is a reality and cannot be disregarded.

Economists, professional investors, CEOs of large companies, governors and even "oracles" have not shown great ability to explain what in fact happens in the economy these days - whether it is actually possible or not.

In the field of the economy there is a perspective that draws special attention: the behavioral economics, and in particular, neuromarketing.

2. Neuromarketing and Consumer's Decisions

Varian (2006) considers that the existing models were not sufficient to explain the phenomena of human behaviors, especially those for consumption. Varian (2006, p. 586) states that the economic model of consumer choice that usually is studied is simple and elegant. It constitutes a reasonable starting point for many types of analysis. However, it is definitely not complete. In many cases it is necessary to use a deeper model of consumer behavior to describe, more precisely, the decision-making.

Ross *et al* (2008) presented an interesting study using Picoeconomics, or analysis of consumption patterns, which defines how the modeling of intertemporal choices in a market where the sub-personal balance between different interests is achieved through negotiation. The research is part of the Neuroeconomics analysis, with the support of laboratory research using imaging techniques. The

authors present the methods adopted by man for self-control and to prevent a range of choices of excessive short-term solutions. Particular focus is given to the rules of personal conduct self-imposed, in which are considered the strategies based on the concept that behavior is a balance among games of negotiation considering sub-personal interests.

Traditionally, marketers and advertisers have long utilized focus group-based research as a means of getting responses to products and communications of a brand. Though the consumer-driven marketplace is changing and so the consumer opinions and reactions. The new technologies that allow marketers to scientifically understand the mind of consumer are now being used. Through brain activity-based research, marketers can pinpoint what exactly drives people to buy a product and uncover how the brain responds to various advertising and marketing tactics (see Williams, 2010).

On this sense, neuromarketing uses new technologies to measure the brain activity of consumer subjects as a way to discover how people respond to products and marketing messages. "The drive behind neuromarketing is to discover how consumers are actually responding to marketing messages, not how they report they are responding, or will respond" (Williams, 2010).

The field of behavioral economics is devoted to the study of how consumers actually make their choices [...]. Many of these choices contradict the conventional economic model of "rational" consumers (see Varian 2006, p. 586). The basic line of this approach – neuromarketing - sustains that man actually has a limited ability to make rational decisions.

Buying decisions are not, in truth, necessarily rational decisions, rather they are decisions made deep within the brain and based on a mix of thoughts and feelings. These decisions take place in the subconscious part of the brain (Williams, 2010).

In decision-making process, the conventional model has dissonant anomalies about consumer theory, which have been effectively and systematically discovered by this field of study. Among such contradictions arising out of the tests made by this approach, some topics may be highlighted, as they are the context effect on consumer choice; uncertainty; time and strategic interaction; or social standards, for example.

The choices based on the concept of uncertainty also tend to influence the consumers decisions, basically because most people demonstrate that they are adverse to loss and defend their current positions at any way. This shows that the consumption act decision is much more tortuous than it seems to be.

Another decisive factor is time, which presents specific peculiarities such as discount situations, or self-control.

Strategic interaction and social norms are also factors or explanatory variables for the decision. It may be considered that the inherent relationship is based on sociological behaviors. A good example of the functioning of this variable is the analysis based on game theory which culminated in the emergence of behavioral theory of games, which considers the bias caused by emotional components such as joy, surprise, anger, fear, etc.

Neuromarketing constitutes in fact a strand of behavioral economics, indicating the path to the relevant analysis on the influences of human irrationality in decision-making. Neuromarketing is the union of Neuroscience and Marketing to explain how consumer really takes his buying decision. Its mission is the consumer brain research (see Lindstronm, 2010, p. 150).

Therefore, neuromarketing has emerged as a science which intends to explain processes and can test campaigns, applications, more exact shapes sensations, using neurosciences as an ally of marketing (see Rodrigues, 2011, p. 02).

However it is necessary to have a broader idea about neuromarketing once it is composed by various disciplines as much as neuroscience and marketing, such as:

- Economics;

- Quantitative Methods;

- Psychology;

- Biology;

- Pharmacology;

- among others.

This seems to bring a fresh realistic approach about this aspect of behavioral economics. The truth is that the global crisis brings evident some barriers to the good performance of companies in the market. Unless the company holds a monopoly, it will devote a good part of its efforts to sell its products and services. Clearly this is not easy to fulfill, once:

- there is a range of professional buyers who are very well prepared;

- there is a stiffer competition;

- there is an extension of the sales cycle;

- today a company sells and buys in teams;

- there is greater resistance to traditional marketing techniques when a sale is near to be closed.

Consequently, neuromarketing appears as a probable solution when these difficulties come out or, at least, neuromarketing emerges as a possible alternative for agents to get better results on the market.

3. Neuromarketing Clinical Techniques

At first modern psychology was combined with the technology to explain decision making processes within the brain. Later, economic behavioral decision making theory was revised in the light of neuroscientific research results. It was just in recent years that consumer behavior and marketing research has started looking towards neuroscience for answers to salient consumer decision motives. It is from here that neuromarketing started to emerge (Simson, 2010).

Recently it has become evident that emotions have a very important role in the decision making processes and are particularly significant in decisions within consumer behavior.

Studies involving neurosciences, when studying emotional processes, show that emotions work primarily and it is not rationality that acts the first role in influencing decision making, perception, cognition or the behavior of an individual. Emotional processes' understanding is fundamental for marketing development and for advertising campaigns. In fact, successful branding and advertising depend on understanding and developing an emotional appeal towards consumers. However, traditional research methods cannot uncover these emotional processes as they are only reflected in the brain and through physiological reactions.

The real reasons to understand the consumers' perception of advertizing are not really caught by traditional marketing and brands. Marketing cannot well understand the consumers' attention and behavior. For this understanding, new techniques are necessary and the role of neuromarketing is vital on this research. Traditional research methods can become more accurate and advertising effectiveness can be increased by using the results of the application of these techniques. Although neuromarketing cannot be used to guide behavior, it can be used to develop the understanding of how emotional processes influence perception and behavior.

Considering the need of studying the human brain, in order to understand the decision making process, Williams (2010) refers that neuromarketing research is usually conducted through one or more of the following clinical techniques:

- Functional magnetic resonance imaging (fMRI). A technique that shows what parts of the brain are active by detecting changes in blood flow and the amount of oxygen consumed in different areas. The more active an area, the more oxygen and blood flow required. Subjects are put into a cylindrical imaging device and exposed to marketing material.

- Electroencephalography (EEG). The EEG technique measures the electrical activity of the brain (neurons) as recorded by electrodes placed on a subject's head. Subjects are either given special EEG headsets to wear while exposed to marketing materials. While not as specific or accurate as fMRIs, EEGs are much less intrusive and can also be conducted at about the same cost as a typical focus group, making them extremely accessible to most businesses.

- Eye tracking. Eyes are the main focus in this technique as the location and pattern of a subject's gaze is studied to determine which images or portions of an image illicit the most attention.

- Galvanic skin response (GSR). GSR is a technique that measures the subtle changes in skin (such as temperature and sweat) that occur in conjunction with certain emotions.

- Applied neuroscience. This is a technique that involves no scanning or monitoring of any kind. Instead this technique is market research with a focus on the foundations of neuroscience to train marketers and sales teams to design pitches, offers and marketing messages that appeal to the brain on a subconscious level. This technique is based off of secondary research - or research already conducted by others - and is therefore much more accessible to smaller businesses and nonprofits.

4. What Happens in the Brain of the Consumer

People tend to look at the world under their particular perspective. This is used to filter and to process the perceptions, extracting the significance of many environmental information. This occurs because the brain tries to be the most efficient possible seeking causal relationships between multivariate information, generating finally the perception. This perception, in synthesis, is nothing more than a choice among several possible interpretations for options. After all, if the brain were to process and record all the information provided, probably would collapse.

But after all, how does the consumer's perception work in the brain? The part of the brain responsible for processing the signals from the initial vision is the occipital cortex (which is on the back of the brain). After the occipital cortex, information flows to the front of the brain, specifically towards the frontal lobes. The information takes two paths: primary and secondary. The first crosses the top of the brain, extracting information about where the objects are located in space in relation to the body. Already the secondary is a road that follows through the temporal lobes, located above the ears, and processes the visual information in order to categorize what the person sees. These two routes shall be coordinated by and among themselves, so that the end result is the full perception of the information that the eyes transmit (see Berns, 2008, p. 33).

Neuroscientists believe that visual perception is largely the result of statistical expectations. The perception is the way the brain interprets ambiguous cues using the most likely explanation, which is a direct result of past experiences (see Chavaglia and Filipe, 2011, p. 02).

The perception shapes what will be stored by the rest of the life of a human being, for example, the creation of an anchor price. Memory can be defined as the sum of all existing memories into consciousness, as well as skills that determine the extent and accuracy of these memories (see Eduardo, p. 324). The memory of a person is subdivided into short-term memory (working memory) and into long-term memory. The short-term memory meets a lot of information available to us and that we realized in the environment for the present time; and the long-term memory refers to information that people hold during a long time, in other words, is the memory that we will use to remember through our past experiences. This process lies in the region of the brain called the hippocampus, which acts as if it is - in a military language - an advanced command post.

The hippocampus will always be selecting what goes in working memory and what goes into the long-term memory. These events depend on the personal characteristics of each one of us, namely our past experiences. In general terms, each person will present sensitivity according to his past experiences associated with his genetic formation. Some of these people can become more sensitive to the colours of the product, other to the architecture of the object itself, some to the price of the product and so on considering all other categorizations about the product.

In the case of "anchoring", let's consider someone who runs a dealership of vehicles to buy his first car. This person arrives at the booth of popular cars and when he questions the price of a particular car, this price will be perceived as working memory and after then it is written in long-term memory, creating the effect of anchoring for many following years, because whenever this consumer back to the dealership to buy the same type of car his long-term memory will remember him the anchor price proposed in first purchase.

This mechanism works in the sense that the brain stores the information for a brief period (working memory) and then he separates and erases what the brain does not consider as being important.

In this way, anchoring occurs in the sense that the base retail price or suggested by is perceived in the mind of the consumer in a way that this information will influence all his future purchases of that product.

5. The Effect of Anchoring in Decisions

The ultimate goal of this study is to verify the existence of the anchoring effect of prices in consumer decision of students from business courses of the city of Belém – PA (Brazil).

The neuromarketing, instead of nailing the traditional consumption theory, accepts that the decision is extremely influenced by how the choices are available or how they are placed in context.

The effect of context on consumer choice can be subdivided as follows: buoying effect; anchoring effect; effect of excess options; and preferences built.

The anchoring effect will serve as a parameter to this study. The idea on the effect of anchoring is that people's choices can be influenced by completely spurious information (see Varian, 2006, p. 590).

What really matters in anchoring situation on consumption is how a number influences decisions of people, i.e. if a person or a group of people is exposed to any information about a product pricing, he will be influenced to be based on this anchoring price as a parameter to his buying decisions for that specific product. The suggested number can only be considered an anchor if the person is interested in buying the product.

What happens to people in this situation is that they tend to be influenced by information available in the environment and at the same time, after the decision is made, they cling strongly to defend this decision, at any cost.

After the "anchor" is created in the mind of the consumer, he responds not only for the current purchase, but also for all the future purchases of that product. Ariely (2008, p. 22) classifies this as an arbitrary coherence. That is, the initial prices are largely arbitrary and can be influenced by random questions and answers; but, once defined in the consumer's mind these prices set up not only what the consumer is willing to pay for something, but also what this consumer is willing to pay for related products.

The act as a whole can be presented in the form of procedure: setting the scene, anchor attachment, factor decision, and repeated purchase. To better illustrate this procedure, the following scheme is presented:

Figure 1- Anchoring Process in Consumption

Presentation of the context = > anchor factor = > Attachment decision = > Purchase repetition.

- Presentation of the context - the consumer faces the information coming from the external environment, i.e. categories shown for each product itself.

- Anchor factor - in this step of the process anchoring itself is formed. Perceived external information will be fixed in the consumer's mind.

- Attachment to decision - after being created, the anchor price will be a standard in the consumer's

decision, i.e. the consumer will defend his choice at any cost.

- Purchase repetition / Repetition of the pattern - this is the step on which the consumer (already properly anchored) reflects the effect on a future purchase, i.e. each time that this consumer is going to compare prices of a given good, in which the anchor occurred, he necessarily and unconsciously will use the price of the first acquisition.

6. The Study

For this study, the following objectives were defined:

- seeing the effects of anchoring in consumption decisions;

- presenting the results of the effect of anchoring in chocolate consumption in students studying business administration in the city of Belém – PA (Brazil).

It is intended to address the study considering the theory of behavioral economics, only for students of undergraduate courses in business (Administration, Accounting, Economics). For this, it was necessary to identify the behavior of these students before a decision-making situation of consumption. And for that, 300 people belonging this population were interviewed.

Considering the aims of the study and considering that the study on neuromarketing is essential, it permits to meet the demand for more precise tools in the understanding of the consumer behavior. The purposes of the study reflect the need of such kind of tools, indicating the existence of a way that permits a better understanding of this branch of the economic science.

The lack of specific research on this topic shows, in fact, the importance of this study, in academia and business. In addition, this study fills an existing demand for epistemological knowledge about how the human being takes economic decisions.

Methodologically, this study is supported in the existing literature, uses a well defined and contextualized population, exposing and describing its characteristics, and considers a sample by collecting data from the population, the students of management courses in the city of Belém – PA.

Precisely, the universe for the research is the group of people who attend business courses in the city of Belém – PA, where the sample was taken on the basis of the students of the central region of the city of Belém - PA. The sample of 300 people was defined and collected using the criterion of accessibility.

7. Study Results

The experiment was conducted in a way that a leaflet with a picture of a famous (and expensive) brand of chocolate was introduced to some students of management courses, in which they were asked if they would pay an amount equal to the last two numbers of their I.D. (identity document).

In a second moment, students who responded yes to the first question were separated and it was asked to them what would be the maximum value that they would pay by the chocolate.

Students who had the last two digits of the I.D. number larger than 50 were available to pay on average R$ 25.00 by chocolate; those students who have submitted the last two digits of the I.D. number less than or equal to 50 were available to pay a maximum value of R$ 16,00 (see figure 1).
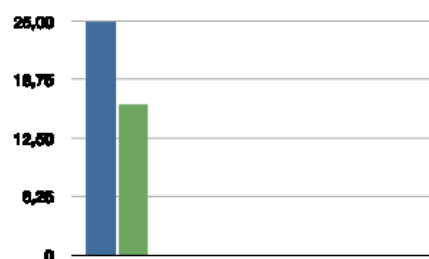

Figure 1 - Average of maximum value paid for the product (*Source: Own research*).

This result indicates that students were strongly influenced by the value of the last two digits of the I.D. number, confirming the existence of the anchor factor in the determination of the maximum values of payment by the chocolate, i.e. people who formed a anchoring price above fifty were willing to pay more for the chocolate, while people who formed an anchor price less than fifty have shown to be prone to pay less for the chocolate.

8. Conclusions

In this study, an analysis of neuromarketing importance was made. As could be seen, it is nowadays a fundamental branch of neuroeconomics for the understanding of human decisions. For that, some techniques are used to study what happens in the brain of the human being. The aim is to understand the decision-making process of the consumer. In this study, the particular goal of the analysis was to verify the anchoring effect of prices in this decision process.

People can be influenced by apparently irrelevant information in the purchasing process of a product or service.

On the basis of the assumptions of behavioural economics analysis, in particular neuromarketing which seeks the understanding of phenomena relating to consumer behaviour through empiricism derived from specific tests on the subject, it can be concluded that the effect of anchoring in fact exists in the studied situation. This scenario indicates that the rationality of students management courses in the city of Belém - PA is limited in this situation of consumer decision.

As well as in everyday life, certain aspects of economic life can be misunderstood. However, this does not prevent one from saying that the anchoring effect affects the decisions of people in other situations of consumption of goods or services as well. In other words, people are subject to make their decisions based on consumption's information which contents influence them in an unintended or unconscious way. These results contradict the dominant assumption in economic theory, which states that individuals always optimize their results by means of rational decisions at the moment of products' purchase or sale.

These outcomes are intriguing but cause some sense of helplessness in the face of economic decisions about day by day lives, because they really indicate the existence of such kind of effects. The existence of these effects may help economic agents to make their economic decisions. After all, if one now has the conscience of the existence of the behavioural variable and that it has a major impact on the decisions, it is reasonable to assume that economic agents are now more able to make better decisions. These decisions are based on the information designed under this optic, which is the analysis of behavioural economics, in particular, neuromarketing.

The industrial exploitation of neuroscientific research is an important reality and it can be additionally explored in future research. It has also an enormous potential application in healthcare and other domains. These domains may include for example new drugs, diagnostics, medical devices, brain health and training programs, software, etc.

The utilization of expensive equipments may be sometimes a limitation to research. However, if they are available the investigation may go faster. In the neuromarketing area it is important to understand the behavior of agents and, for that, the physical study of the brain may contribute considerably to get important results in this area. A research on this basis is projected using some medical equipments, for the support of the analysis.

The role of economic and social value of neuroscience has been often discussed in terms of technical possibilities. Important advances may be got. In terms of psychological interventions and ethical consequences the relevance of the discussion is also very pertinent. Marketing has now to be redefined. The limits of the utilization of new techniques and technologies and the limitations of the human being must be considered.

9. Acknowledgement

References

[1] Akerlof, G. and Shiller, R. J. (2010). *O espírito animal.* São Paulo: Campus.

[2] Ariely, D. (2008), *Previsivelmente Irracional.* São Paulo: Campus.

[3] Bechara, A. and Damasio, A. (2005). The somatic marker hypothesis : A neural theory of economic decision. *Games and Economic Behaviour*, 52, 336-372

[4] Berns, G. (2009), *O iconoclasta*. Rio de Janeiro: Best Seller.

[5] Camerer, C., Loewenstein, G., and Prelec, D. (2005). Neuroeconomics: how neuroscience can inform economics . *J . Econ. Lit.* 43, 9–64.

[6] Camerer, C. Rabin, M. and Rubinstein, A. (2005), *Discussion of behavioral economics.* New York: New York University.

[7] Carlos, A. P. G. Gonçalves, R. R. Santacruz, R. and Matesco, V. R. (2007), *Economia Aplicada.* Rio de Janeiro: FGV.

[8] Carvalho, J. E. (2009), *Neuroeconomia: Ensaio sobre a sociobilologia do comportamento.* Lisboa: Sílabo.

[9] Chavaglia, J. N. and Filipe, J. A. (2011), A View of common property Through Neuroeconomics in the context of Decision-Making processes. *International Journal of Academic Research - IJAR.*

[10] Chavaglia, J. N. (2009), *O futuro da analise econômica.* Belém: Webartigos.

[11] Cohen, D. (2011), *A linguagem do corpo.* Petrópolis: Vozes.

[12] Gino, F. and Pisano, G. (2007), *Toward a Theory of Behavioral Operations.* Boston: Harvard University.

[13] Lopes, L. M. and Vasconcellos, M. A. S. (2000), *Manual de Macroeconomia.* São Paulo: Atlas.

[14] Marx, K. (1982), *Para a Critica da Economia Política; Salário, Preço e Lucro; O Rendimento e Suas Fontes.* São Paulo: Abril Cultural.

[15] Mlodinov, L. (2008). *O Andar do Bêbado: Como o Acaso Determina Nossas Vidas.* Rio de Janeiro: Zahar.

[16] Nogami, O. and Passos, C. R. M. (1999), *Princípios de Economia.* São Paulo: Pioneira.

[17] Peters, T. (1998), *O Circulo da Inovação.* São Paulo: Harbra.

[18] Pindyck, R. (2002), *Microeconomia.* São Paulo, Pearson.

[19] Renvoisé, P. and Morin, C. (2009), *Neuromarketing: o centro nevrálgico da venda.* Lisboa: Smartbook.

[20] Rodrigues, F. (2011), *Influência do Neuromarketing nos processos de tomada de decisão.* Viseu. Psicosoma.

[21] Ross, D., Sharp, C., Vuchinich, R. E. and Spurrett, D. (2008). *Midbrain Mutiny: The Picoeconomics and Neuroeconomics of Disordered Gambling*. MIT Press.

[22] Sandroni, P. (2002), *Novíssimo Dicionário de Economia.* São Paulo: Best Seller.

[23] Simson, A. K. (2010), *Neuromarketing, emotions, and campaigns*, Master Thesis, in http://studenttheses.cbs.dk/bitstream/handle/1041 7/950/annette_kortovna_simson.pdf?sequence=1.

[24] Thaler, R. H. and Sunstein, C. R. (2009), *Nudge*. Lisboa: Academia do livro.

[25] Varian, H. R. (2006), *Microeconomia.* Rio de Janeiro: Campus.

[26] Vergara, S. C. (2004), *Projetos e Relatórios de Pesquisa em Administração.* São Paulo: Atlas.

[27] Williams, J. (2010), *Neuromarketing: When science and marketing collide.* In http://info.4imprint.com/wp-content/uploads/1P-07-0710-July-Blue-Paper-Neuromarketing.pdf

Statistical Queuing Theory with Some Applications

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Abstract— **An overview of theory of queues, single node and in network, is presented in this paper. In addition some applications are outlined. Some very well-known and others more uncommon.**

Keywords— *Queues, networks of queues, applications.*

1. Queues

Consider a Service Centre at which arrive units, the customers, requiring service to other units, the servers, with or without distinction among customers and servers.

The most challenging situations in these systems study, subject matter of Statistical Queuing Theory, occur when it is assumed that:

- Customers arrivals are a stochastic process,
- Each server spent time to supply to each customer the required service is a random variable.
- Other relevant factors are:
- The number of servers that may be finite or infinite, constant or variable,
- If the number of servers is finite, some customers will have to wait to be served. The waiting capacity, that may be finite or infinite, is the maximum number of customers that may stay in the Service Centre waiting to be served. The system capacity is the maximum number of customers, being served or waiting for service, which are allowed to stay in the Service Centre simultaneously. When a customer arrives at a Service Centre with complete capacity it is considered lost to the system. So the queue systems with finite capacity are systems with losses.
- If the number of servers is infinite a customer that arrives finds immediately an available server. So there is no queue in the formal sense of the term. The queue systems with infinite servers are systems with neither waiting nor losses.
- The queue discipline is the method as the customers are selected by the servers or vice-versa. Some examples of queue disciplines are:
  - "First come-first served" (**FCFS**);
  - "Last in-first out" (**LIFO**);
  - "First in-first out" (**FIFO**);
  - "Processor sharing" (**PS**);
  - "Service in Random Order" (**SIRO**);
  - "Priority" (**PRI**);
  - "General Discipline" (**GD**).

The arrival process is usually characterized by the length of the time probability distribution between two successive arrivals of customers at the Service Centre: the inter-arrivals time. It may be deterministic or stochastic. There are models where batch arrivals are considered: the number of customers, arriving at each instant of the sequence of the arrivals instants, is a random variable R that can assume integer values greater than 1 - see, for instance, Shanbhag (1966). The arrival process may depend or not on the number of customers present at the Service Centre. Sometimes refusal situations are considered: the customer arrives and refuses to enter in the Service Centre because there are too many customers waiting to be served. And also renounce situations: the customer is already in the Service Centre and leaves it because it thinks that has waited a too long time.

The service process is specified indicating the length of the time probability distribution that a customer spends being attended by a server: the service time. There may be deterministic or stochastic service times.

A Service Centre which has associated a service process, a waiting capacity and a queue discipline is a node. A node with the respective arrival process is a queue.

The Kendall notation, see Kendall (1953), for describing queues is v/w/x/y/z where

- *v* denotes the arrival process (D, deterministic; M, exponential; E_k, Erlang (k); G, others),
- *w* denotes the service process (D, deterministic; M, exponential; E_k, Erlang (k); G, others),
- *x* denotes the number of servers,
- *y* denotes the system capacity,
- *z* denotes the queue discipline.

If y is not mentioned it is supposed to be infinite. If z is not mentioned it is supposed to be FCFS.

2.   Networks of Queues

A network of queues is a collection of nodes, arbitrarily connected by arcs, across which the customers travel instantaneously and

- There is an arrival process associated to each node,
- There is a commutation process which commands the paths of the various costumers.

The arrival processes may be composed of exogenous arrivals, from the outside of the collection, and of endogenous arrivals, from the other collection nodes.

A network is open if any customer may enter or leave it. A network is closed if it has a fixed number of customers that travel from node to node and there are neither arrivals from the outside of the collection nor departures. A network open for some customers and closed for others is said mixed.

The commutation process rules, for each costumer that abandons a node, which node it can visit then or if it leaves the network. In a network with J nodes, the matrix

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1J} \\ p_{21} & p_{22} & \cdots & p_{2J} \\ \vdots & \vdots & & \vdots \\ p_{J1} & p_{J2} & \cdots & p_{JJ} \end{bmatrix}$$

is the commutation process matrix, being p_{jl} the probability of a customer, after ending its service at node j, go to node l, $j,l = 1,2,...,J$. The probability $q_j = 1 - \sum_{l=1}^{J} p_{jl}$ is the probability that a customer leaves the network from node j, $j = 1,2,...,J$.

A network of queues with infinite servers in each node, with Poisson process exogenous arrivals, may be looked like an M/G/∞ queue. The service time is the sojourn time of a customer in the network. Denote S the sojourn time of a costumer in the network and S_j its service time at node j, $j = 1,2,...J$ Be $G(t)$ and $G_j(t)$ the S and S_j distribution functions, respectively and $\overline{G}(s)$ and $\overline{G}_j(s)$ the Laplace Transforms. If

$$\Lambda = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \vdots \\ \lambda_J \end{bmatrix}$$

is the network exogenous arrival rates vector, where the rate λ_j is the exogenous arrival rate at node j and $\sum_{j=1}^{J} \lambda_j = \lambda$, making

$$\Lambda(s) = \begin{bmatrix} \lambda_1 \overline{G}_1(s) \\ \lambda_2 \overline{G}_2(s) \\ \vdots \\ \lambda_J \overline{G}_J(s) \end{bmatrix}$$

and

$$P(s) = \begin{bmatrix} p_{11}\overline{G}_1(s) & p_{12}\overline{G}_2(s) & \cdots & p_{1J}\overline{G}_J(s) \\ p_{12}\overline{G}_1(s) & p_{22}\overline{G}_2(s) & \cdots & p_{2J}\overline{G}_J(s) \\ \vdots & \vdots & & \vdots \\ p_{J1}\overline{G}_1(s) & p_{J2}\overline{G}_2(2) & \cdots & p_{JJ}\overline{G}_J(s) \end{bmatrix}$$

it results

$$\overline{G}(s) = \lambda^{-1}\Lambda^T(s)(I - P(s))^{-1}(I - P)A$$

where *A* is a column with J 1`s, for the Laplace Transform service time (Ferreira and Andrade, 2010d).

The networks of queues with infinite servers in each node have interesting applications in Logistics, based on the failures of the transport vehicles that allow computing important measures of performance. See, for instance, Ferreira and Filipe (2010a,b), Ferreira, Andrade and Filipe (2009) and Ferreira *et al* (2009).

3.   Stochastic Processes in Queues

A population is a set of objects that share common characteristics. Often, in practical situations, it is important to study statistically the expansion, or the reduction, of a population in order, eventually, to control it. If N (t) is the size of the population at instant t, the states of a population process are the various values that can be assumed by N (t) and the probability that N (t) =n, n=0, 1, 2… is denoted pn (t).

There is a birth when a new member joins the population. There is a death when a member leaves the population.

A population process is a Markov process if the changing from a state to other, eventually the same,

transition probabilities depend only on the initial state and not on the mutations experienced by the process till the arrival at the present state.

The probability distribution that rules the number of births and deaths in a certain time interval, in a Markov process, depends only on the interval length and not on the initial state.

A queue system is a birth and death process with a population composed by customers receiving a service or waiting for it. There is a birth when a customer arrives at the Service Centre. There is a death when a customer abandons the Service Centre. The state of the system is the number of the customers in the Service Centre. The population process is the most important quantity of interest in the study of queues. In particular, it is important the search for a stationary distribution for it. In this situation pn (t) do not depend on time and is denoted pn. Usually pn is obtained computing $\lim_{t \to \infty} p_n(t)$. The pn (t), depending on time, characterize the queue system transient behavior. The probabilities pn characterize the queue system stationary state, also called equilibrium state.

Other important quantities, that are measures of the queuing system performance, are the waiting time, also called queue time- the time that a customer spends in the system waiting for the service - and the sojourn time- the total time that a customer spends in the system: queue time plus service time.

Often it is difficult to obtain treatable formulae for the population process, the waiting time and the sojourn time and even to make an analytic study. So numerical and simulation methods are intensively used.

Based on the transient and stationary probabilities of infinite servers systems there are interesting applications in:

- *Financial problems*
    The study of the sustainability of a pensions fund. See, Ferreira and Andrade (2011h) and Figueira and Ferreira (1999).
- *Energy problems*
    How to deal with motor cars in a situation of scars energy – for instance in the end of oil reserves. See Ferreira, Filipe and Coelho (2008, 2011).

4. Traffic Intensity

The traffic intensity, ρ, is the most important parameter in queues study. See, for instance, Cox and Smith (1961). It is given by

$$\rho = \lambda \alpha$$

where λ is the arrival rate of the customers and α the mean service time.

Little's formula, see also Cox and Smith (1961), is, perhaps, the most popular result in queuing theory. It is a very general formula valid for any queue system that attains the stationary state. It relates the mean number of customers in the system, N, with the mean sojourn time of a customer, W, through the arrival rate, λ:

$$N = \lambda W.$$

The Pollaczeck-Khinchine formula (Cox and Smith, 1961) is used, for the M/G/1 queue, to evaluate the mean waiting time of a customer in the system:

$$W_s = \alpha \frac{\rho}{1-\rho} \frac{1+C_s^2}{2}$$

C_s is the service time coefficient of variation.

The mean sojourn time of a customer in the system is then

$$W = W_q + \alpha .$$

5. Busy Period

The busy period of a queue system begins when a customer arrives there, finding it empty, and ends when a customer leaves the system letting it empty. Along the busy period there is always at least one customer in the system. In any queue system there is a sequence of idle periods and busy periods. In systems with Poisson arrivals the idle period length is always exponential. The statistical study of the busy period is always a very difficult task. In general the busy period length is related with the transient behavior (see, for instance, Ferreira and Andrade, 2009a,b). An idle period followed by a busy period is a busy cycle.

For a M/G/∞ queue, if the service time distribution function belongs to the collection

$$G(t) = 1 - \frac{\left(1-e^{-\rho}\right)\left(\lambda+\beta\right)}{\lambda e^{-\rho}\left(e^{(\lambda+\beta)t}-1\right)+\lambda}, t \geq 0, -\lambda \leq \beta \leq \frac{\lambda}{e^{\rho}-1}$$

the busy period length distribution function is

$$B^{\beta}(t) = 1 - \frac{\lambda+\beta}{\lambda}\left(1-e^{-\rho}\right)e^{-e^{-\rho}(\lambda+\beta)t}, t \geq 0,$$

$$-\lambda \leq \beta \leq \frac{\lambda}{e^{\rho}-1},$$

a mixture of a degenerate distribution at the origin and an exponential distribution (Ferreira and Andrade, 2009a,b).

The busy period of the $M|G|\infty$ queue may be used to model socio-economic problems as, for example

- *Disease problems*

  An epidemic situation may be assumed as being a busy period. An idle period is the one at which there is disease absence,

- *Unemployment situations*

  An unemployment period is a busy period, ironically, and an idle period is a full employment period.

In the modeling of these problems it is also necessary to consider the properties of the transient probabilities. See Ferreira and Andrade (2010e).

6.   More Applications

Statistical Queuing Theory is applied, for example, to intelligent transportation systems, call centres (see Ferreira and Andrade, 2010a), PABXs, telecommunications networks, advanced telecommunications systems and traffic flow. The networks of queues are used to reduce the waiting times in the hospitals. Another example of application of the networks of queues are the compartment models, in which infinite servers nodes are considered, important in Biology and in the study of hierarchical systems (Ferreira, 1987).

Agner Krarup Erlang, a Danish engineer who worked for the Copenhagen Telephone Exchange, published the first paper on queuing theory in 1909 (Erlang, 1909). The famous Erlang loss formula (Erlang, 1917)

$$p_m = \frac{\rho^m}{m!}\left(\sum_{i=0}^{m}\frac{\rho^i}{i!}\right)^{-1}$$

is the stationary probability that in the M/M/m/m queue the m servers are occupied (Ferreira and Andrade, 2010a). It is very much used in call-centres management to evaluate the probability of a call lost.

Leonard Kleinrock, in the early 1960s, performed an important work on queuing theory used in modern packet switching networks (Kleinrock, 1975, 1976).

7.   Product   Form   Equilibrium Distribution

The first important result in the network of queues area was Jackson networks - an example of open networks - for which efficient product form equilibrium distribution exists (Jackson, 1957).

In a product form solution the equilibrium state probabilities are of the form

$$\pi(\pi_1, x_2,...x_J) = C\pi_1(x_1)\pi_2(x_2)...\pi_J(x_J)$$

where C is a normalizing constant chosen to make equilibrium state probabilities sum to 1 and $\pi_i(.)$ represents the equilibrium distribution for queue $i, i = 1,2,...J$.

The BCMP (Baskett, Chandy, Muntz and Palacios, 1975) networks are a generalization of Jackson networks, considering several classes of customers.

For the Gordon-Newell networks-that are closed networks - product form equilibrium distribution also exists (Gordon and Newell, 1967).

References

[1] Andrade, M. (2010), "*A Note on Foundations of Probability*". Journal of Mathematics and Technology, Vol. 1 (1), pp 96-98.

[2] Basket, F., Chandy, M., Muntz, R. and Palacios, J. (1975*), "Open, closed and mixed Networks of Queues with Different Classes of Customers",* Journal of ACM 22, pp 248-260.

[3] Cox, D. R. and Smith, W. L. (1961), "*Queues*". London: Methuen.

[4] Cox, D. R. and Miller, H. D. (1965), "*The Theory of Stochastic Processes*". London: Chapman and Hall.

[5] Disney, R. L. and König, D. (1985), *"Queueing Networks: a Survey of their Random Processes*". Siam Review 3, pp 335-403.

[6] Erlang, A. K. (1909), *"The Theory of Probabilities and Telephone Conversations"*. Nyt Tidsskrift for Mathematic B 20.

[7] Erlang, A. K. (1917), *"Solution of Some Problems in the Theory of Probabilities of Significance in Automatic Telephone Exchanges",* Post Office Electrical Engineers' Journal 10, pp 189-197.

[8] Ferreira, M. A. M. (1987), *"Redes de filas de espera"*. Master thesis presented at IST-UTL.

[9] Ferreira, M. A. M. (2010), "*A Note on Jackson Networks Sojourn Times*". Journal of Mathematics and Technology, Vol. 1, No 1, pp 91-95.

[10] Ferreira, M. A. M. and Andrade, M. (2009a), *"M*$|G|\infty$ *Queue System Parameters for a Particular Collection of Service Time Distributions".* AJMCSR-African Journal of Mathematics and Computer Science Research Vol. 2(7), pp 138-141.

[11] Ferreira, M. A. M. and Andrade, M. (2009b), *"The Ties Between the M/G/∞ Queue System Transient Behavior and the Busy Period"*. International Journal of Academic Research 1 Vol. (1), pp 84-92.

[12] Ferreira, M. A. M. and Andrade, M. (2010a), *"M/M/m/m Queue System Transient Behavior"*. Journal of Mathematics and Technology, Vol. 1 (1), pp 49-65.

[13] Ferreira, M. A. M. and Andrade, M. (2010b), *"Looking to a M/G/∞ System Occupation Through a Riccati Equation"*. Journal of Mathematics and Technology, Vol. 1 (2), pp 58-62.

[14] Ferreira, M. A. M. and Andrade, M. (2010c), *"M/G/∞ Queue Busy Period Tail"*. Journal of Mathematics and Technology, Vol. 1 (3), pp 11-16.

[15] Ferreira, M. A. M. and Andrade, M. (2010d), *"Algorithm for the Calculation of the Laplace-Stieltjes Transform of the Sojourn Time of a Customer in an Open Network of Queues with a Product Form Equilibrium Distribution, assuming Independent Sojourn Times in each Node"*. Journal of Mathematics and Technology, Vol. 1 (4), pp 31-36.

[16] Ferreira, M. A. M. and Andrade, M. (2010e), *"M/G/∞ System Transient Behavior with Time Origin at the Beginning of a Busy Period Mean and Variance"*. Aplimat- Journal of Applied Mathematics, Vol. 3 (3), pp 213-221.

[17] Ferreira, M. A. M. and Andrade, M. (2011a), *"Fundaments of Theory of Queues"*. International Journal of Academic Research, Vol. 3 (1), part II, pp 427-429.

[18] Ferreira, M. A. M. and Andrade, M. (2011b), *"Some Notes on the M/G/∞ Queue Busy Cycle Renewal Function"*. International Journal of Academic Research, Vol. 3 (6), I Part, pp179-182.

[19] Ferreira, M. A. M. and Andrade, M. (2011c), *"M/G/∞ Infinite Queue System Transient Behaviour with Time Origin at an Operation Beginning Instant and Occupation"*. Journal of Mathematics and Technology, Vol. 2 (1), pp 54-60.

[20] Ferreira, M. A. M. and Andrade, M. (2011d), *"Grouping and Reordering in a Servers Series"*. Journal of Mathematics and Technology, Vol. 2 (2), pp 4-8.

[21] Ferreira, M. A. M. and Andrade, M. (2011e), *"Non-homogeneous Networks of Queues"*. Journal of Mathematics and Technology, Vol. 2 (2), pp 24-29.

[22] Ferreira, M. A. M. and Andrade, M. (2011f), *"The M/GI/1 Queue with Instantaneous Bernoulli Feedback Stochastic Processes: A Review"*. Journal of Mathematics and Technology, Vol. 2 (3), pp 27-30.

[23] Ferreira, M. A. M. and Andrade, M. (2011g), *"The Fundamental Theorem in Queuing Networks"*. Journal of Mathematics and Technology, Vol. 2 (3), pp 48-53.

[24] Ferreira, M. A. M. and Andrade, M. (2011h), *"An infinite servers Nodes Network in the Study of a Pensions Fund"*. International Journal of Latest Trends in Finance and Economic Sciences, Vol. 1 (2), pp 91-94.

[25] Ferreira, M. A. M. and Filipe, J. A. (2010a), *"Solving Logistics Problems using M/G/∞ Queue Systems Busy Period"*. Aplimat- Journal of Applied Mathematics, Vol. 3 (3), pp 207-212.

[26] Ferreira, M. A. M. and Filipe, J. A. (2010b), *"Economic Crisis: Using M/G/oo Queue System Busy Period to Solve Logistics Problems in an Organization"*. China-USA Business Review, Vol. 9 (9), pp 59-63.

[27] Ferreira, M. A. M., Andrade, M. and Filipe, J. A. (2008), *"The Ricatti Equation in the M|G|∞ System Busy Cycle Study"*. Journal of Mathematics, Statistics and Allied Fields 2(1).

[28] Ferreira, M. A. M., Andrade, M. and Filipe, J. A. (2009), *"Networks of Queues with Infinite Servers in Each Node Applied to the Management of a Two Echelons Repair System"*. China-USA Business Review 8(8), pp 39-45 and 62.

[29] Ferreira, M. A. M., Filipe, J. A. and Coelho, M. (2008), *"A Queue Model for Motor Vehicles Dismantling and Recycling"*. Aplimat- Journal of Applied Mathematics, Vol. 1 (1), pp 337-344.

[30] Ferreira, M. A. M., Filipe, J. A. and Coelho, M. (2011), *"A Queue model- Recycling and Dismantling Motor Vehicles"*. International Journal of Latest Trends in Finance and Economic Sciences, Vol. 1 (3), pp 137-141.

[31] Ferreira, M. A. M., Andrade, M., Filipe, J. A. and Selvarasu, A. (2009), *"The Management of a Two Echelons Repair System Using Queuing Networks with Infinite Servers Queues"*. Annamalai International Journal of Business and Research, Vol. 1, pp 132-137.

[32] Figueira, J. and Ferreira, M. A. M. (1999), *"Representation of a Pensions Fund by a Stochastic Network with Two Nodes: an Exercise"*. Portuguese Review of Financial Markets, Vol. 2, No 1, pp 75-81.

[33] Gordon, W. J. and Newell, G. F. (1967), *"Closed Queueing Systems with Exponential Servers"*. Operations Research 15, pp 254-265.

[34] Jackson, J. R. (1957), *"Networks of Waiting Lines"*. Operations Research 5, pp 518-521.

[35] Kelly, F. P. (1979), *"Reversibility and Stochastic Networks"*. New York: John Wiley and Sons.

[36] Kendall, D. G. (1953), *"The Analysis of Economic Time-Series-Part I: Prices"*. Journal of the Royal Statistical Society. A (General) 116(1), pp 11-34.

[37] Kleinrock, L. (1975), *"Queueing Systems"*, Vol. 1, Wiley, New York.

[38] Kleinrock, L. (1976), *"Queueing Systems"*, Vol. 2, Wiley, New York.

[39] Mathew, L. and Smith, D. (2006), *"Using Queuing Theory to Analyze Completion Times in Accident and Emergency Departments in the Light of the Government 4-hours Target"*. Cass Business School retrieved on 2008-05-20.

[40] Shanbhag, D. N. (1966), *"On Infinite Servers Queues with Batch Arrivals"*. Journal of Applied Probability, 3, pp 274-279.

[41] Syski, R. (1960), *"Introduction to Congestion Theory in Telephone Systems"*. Oliver and Boyd. London.

[42] Syski, R. (1986), *"Introduction to Congestion Theory in Telephone Systems"*. North Holland. Amsterdam.

[43] Takács, L. (1962), *"An Introduction to Queueing Theory"*. Oxford University Press". New York.

[44] Tijms, H. C. (2003), *"Algorithmic Analysis of Queues"*. Chapter 9 in "A First Course in Stochastic Models", Wiley, Chichester.

[45] Walrand, J. (1988), *"An Introduction to Queueing Networks*. New Jersey: Prentice-Hall, Inc.

Implementation of a Program for the Analysis of the Costs of Equipment's Maintenance until the End of their Useful Life

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Abstract - **Companies face nowadays a very competitive environment and they have to be well managed to remain sustainable. For being sustainable the company needs either to increase its prices over time or has to reduce the amount of expenses. Reducing costs may be the best option once the global market is very competitive. This work results from the intention of a company (ME-Construction Company) to get a tool to support the decisions related to the equipment management. The aim is to create a model for the analysis of the costs resulting from using ME-Construction Company's equipments. The studied case is real. This model is the Life Cycle Cost complemented by the Net Present Value and Equivalent Annual Cost. It is worked on a representative sample of the equipment of the company. The application of this model allows the manager to have the estimating tools which may support and justify his decisions in the company. During the equipment's lifetime, he may have the right perception of the evolution of the expenses and income. The company should develop an equipment costing methodology as much effective as possible in order to consider the expenses that are not included in the equipment value and to consider the equipments which release less greenhouse gases contributing to reduce the global greenhouse effect.**

Keywords*—* Life Cycle Cost, Adjusted Cost, Net Present Value, Equivalent Annual Cost.

1. Introduction

Life Cycle Cost (LCC) is a technique of analysis which has been used widely as an engineering tool (for example for supporting a project or an acquisition). It begins to be used now as a management tool (for example for costs analysis). It is mainly a tool that helps engineers thinking as MBA - Master of Business Administration professionals, acting as engineers by connecting engineering decisions to management. LCC helps engineers to have an overview of all expenses associated to productive assets, and to apply their experience about the general performance and about expenses to conjecture about the future, and thus they have access to useful information in order to support their decisions (see Assis and Julião, 2009).

LCC of an asset is the sum of all the expenditures in capital used to support this asset since its conception and manufacture including the operation, until the end of its useful life (White and Ostwld, 1976).

In order to respond to the needs of the companies which have to deal with huge maintenance costs, a model that allows the manager and the engineer to determine the best time to replace the equipment becomes necessary. This model, LCC, will be preferably applied to the equipment of higher initial investment, so that it minimizes the overall cost.

Thus this tool gets particular relevance once it permits to better understand that the important thing is not to know the price of nothing but to know the value of everything (Assis and Julião, 2009).

After a short presentation about costing methodologies for equipments, a model is formulated and validated. The study ends with the presentation of the results and some conclusions and recommendations.

2. Purpose

This study focuses on the implementation of a program for the analysis of the maintenance costs of the equipments until the end of their useful life. The study is developed by constructing a model which permits to increase the visibility of the total of costs that enhances the choice of the best solution for a particular equipment at the time manager has to decide about purchasing or renting or either repair or replace it.

In the specific case of ME – construction company the current problem in the responsible Department for the equipments is the decision of when to replace the equipment. This is, what is the best choice between the replacement options based on all expenses and income. In order to get answers, the equipment manager, usually makes an assessment case by case.

This problem may be overcome by implementing this model for costs and can be simply calculated for equipment that was assessed.

This model considers the end of the equipment lifetime and, through an analysis of the obtained values, permits to answer to some questions of the equipment manager, regardless the equipment is in

the acquisition, the exploration, or deactivation phases.

In this study the **important** to be considered is the feasibility of the model implementation considering that all data presented in the study are "distorted", despite being sustained on real information.

3. Methodology

In order to develop this work, the method of analysis of LCC is used. This model is complemented by the analysis of expenses considering other tools which support the equipment manager, such as the method of Net Present Value (NPV) for the evaluation of projects with the same life span, and the Equivalent Annual Cost (EAC), which permits to compare projects with different life spans.

A problem associated to LCC expenses is related to the uncertainty of the project's future expenditures. To deal with uncertainty, different methodologies will be used, according to the phases of the project. These methodologies are:

- estimation by analogy,

- parametric estimation methods, and

- methods of estimation by engineering procedures.

LCC of an asset may be significantly higher than the initial investment (Woodward, 1997), and in many cases it is set at the first design stage (Fig. 1). However, investment expenses are used by many companies as the main selection criterion for the purchase, or even as the sole criterion (Lindholm e Suomala, 2004). This is due largely to the ignorance of LCC technique, to the lack of a standard or guidelines that support the implementation of this technique, and especially to the lack of data about the past of the assets (Ardit and Messiha, 1999).

When LCC is used as a tool for comparison between different alternatives, its process of calculation indicates, impartially, the solution which has a lower overall expense, based on available information (Freire, 2006). According Hanafizadeh and Latif (2011), one of the most important and frequent decisions that manager face is the selection of new industrial projects. For the analysis of projects, NPV is used for the ones with the same lifetime and EAC is used for different periods. According to Sinclair (2010), EAC can be used as an analysis tool in investment decision, when comparing the annual costs of equipment with different lives spans service and operating expenses.

4. Data Processing

The identification of all involved parcels is presented as a key step in this methodology. The types of costs usually considered in this kind of analysis are:

- investment in acquisition /leasing,

- distribution expenses,

- maintenance expenses,

- operating expenses,

- financial expenses,

- training expenses,

- inventory expenses,

- stop spending;

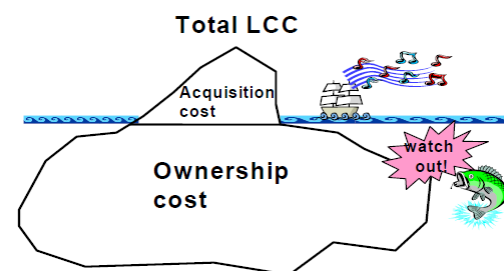- expenses of decommissioning, and

- environmental spending.

Figure 1 - LCC consists in investment in acquisition and property expenses (Dangel, 1969).

Data collection is a very important step, because all the work is supported on the collected data. If the data do not represent the true values, the results will be different from reality. In this study, the collected data represent equipments that belong to the shipyard Porto Alto of ME – Construction Company, particularly, income, assets acquisition, involved costs and actuarial rate.

5. Results and Discussion

Based on the needs of the company, a model was built to help the equipment manager to answer many questions about the three phases of the machine status in the company. The model allows the equipment manager to be able to easily determine the best option when he buys, to know the costs of the equipment during the exploration phase and deactivation phase, knowing at any time if the best option is to rebuild, sell or replace the equipment.

5.1 Acquisition Support

In the model, the option to support the acquisition of equipment permits to compare different brands that have similar characteristics, so that the equipment manager realizes the best brand to choose in a future purchase. Instead of using only historical data so far, the equipment manager may use estimated costs and revenues based on the prediction model, to be able to view the best option to buy, with the values defined by the end of equipment lifetime.

In this evaluation, about the acquisition, LCC was relevant and was complemented by EAC (the 3 equipment have different useful lives). To illustrate,

the calculations were then made for the following three equipments:

- Caterpillar 323 DL cm - 20/106;

- NLC Volvo EC 240 B - 20/501, and

- Komatsu PC 240-6 - 20/857.

In this case, Caterpillar is rented equipment with purchasing option, having been hired in 2006. ME-Construction Company has purchased the other two units in 2004.

The results of LCC for the three equipments are presented in Table 1.

Table 1 - Results to support the acquisition.

	CATERPILLAR 323 D L cm - 20/106	VOLVO EC 240 B NLC - 20/501	KOMATSU PC 240-6 - 20/857
LCC =	244.218 €	223.367 €	271.394 €
NPV =	-76.183 €	-28.996 €	-36.019 €
EAC =	-19.282 €	-5.646 €	-7.013 €

Based on LCC of the three analyzed equipments for the period of their lives, it is possible to conclude that the option to purchase the Volvo EC 240 B NLC is the most profitable option in terms of cost at this time. If the EAC analysis is considered it is possible to conclude that the same option would be the best option, and as the periods of lifetime are not the same, than it is necessary to use the contribution of EAC as a tool to support the decision.

After knowing which of the three assessments of existing equipments has a lower LCC at the time of the evaluation, the evolution of spending over the years may be also compared, as can be seen in the figure 2.
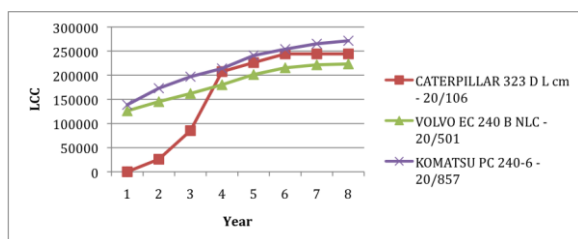

Figure 2 - LCC evolution in the acquisition evaluation.

Considering the LCC analysis over the years, presented in Figure 2, it can be concluded that, given a small project, it is more profitable to rent Caterpillar equipment until the point in which LCC of Caterpillar intercepts LCC of Volvo, which from the third year becomes more profitable until the end of the period (the end of the seven years that were analyzed).

Another evaluation which takes into account the total costs on maintenance is made. It permits to assist the equipment manager in the purchasing decision by looking at the past expenses and the forecasts of the costs for the coming years as shown in the graph in figure 3.
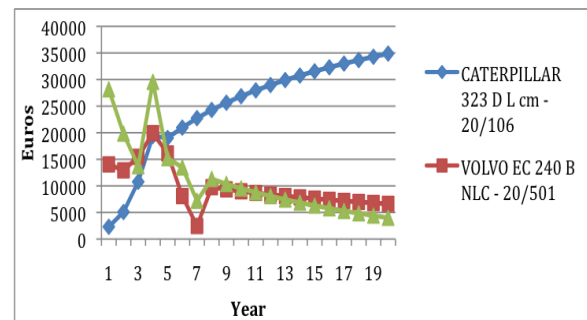

Figure 3 – Adjusted total cost on maintenance of the three equipments.

After analyzing the graphic, and comparing it with data from LCC analysis, it can be noted that the option to acquire Komatsu includes more expenses in the initial phase of its lifetime, and at the end of its life it is expected to have lower total maintenance costs (but as already mentioned, some data are not real). With the data that we have chosen to make the calculations Caterpillar would not be a good option once it may be anticipated that the total adjusted costs for maintenance have a big increase.

The adjusted costs, in this case, were calculated on the basis of the costs of the early years and as it was a rental contract with a maintenance contract included, the initial costs are higher and may deviate from the forecast of future for high values of costs.

5.2 To Rent vs to Buy

To understand what is the best option in case of doubt in the acquisition phase (option to rent or option to purchase), taking into account the existing equipments in the company, the data must be collected by brand. For this option see table 2.

Table 2 – To Buy or to Rent the Assessment (option to buy *vs* rental option).

	Option to buy	Option to rent
Brand/model	CATERPILLAR/14 M	CATERPILLAR/14 M
Year of manufacture	2010	2010
Acquisitions cost (years)	290 000,00 €	
Rental income (annual)		33 333,00 €
Year rental		20
Life (Years)	20	20
Life (hours)	26 923	26 923
Accounting life (years)	16	16
Investment value	290 000,00 €	
Monthly value of mobilization)	1 982,15 €	1 982,15 €
Normal hourly	14,14 €	14,14 €
Residual value	75 000,00 €	
Income (occupancy 70%) (annual)	35 684,62 €	35 684,62 €
Depreciation (annual)	18 125 €	
LCC	322 747 €	441 872 €
NPV	-8 670 €	21 697 €
EAC	-909 €	2 276 €

Renting is the best option because NPV is positive

Also data relating to the rental option is shown with simulated data given by the head of ME-Construction Company and Caterpillar dealer. The prediction model used in this rental or purchasing evaluation is only illustrative of the importance of the

model because the first seven years are simulated in order to obtain a forecast for the next thirteen years. In this case the simulation was done for 20 years. As can be seen in the output of the model in Table 2, it automatically gives information about which choice is more profitable, being the rental option slightly more profitable since the NPV is positive.

In Figure 3 it can be seen on the graphic the logarithm of expenses that will allow to calculate the projected expenditures for future years, based on historical data represented in cash flows, permitting to calculate the results in Table 2.
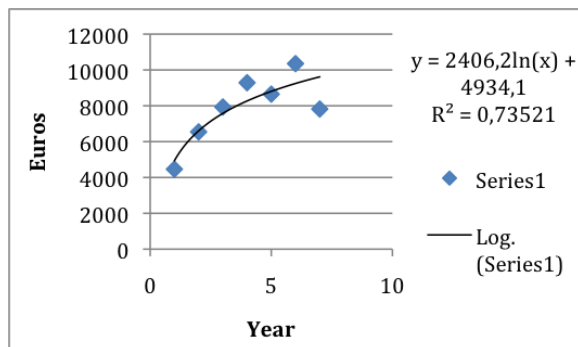

Figure 4 – Historical evolution of the total adjusted annual expenditures of the Caterpillar 14/M acquisition.

With this simulation, the equipment manager can determine easily the best option through the NPV if both have the same lifetime. If the options have different periods of life, what is quite common in this kind of evaluations, EAC is used, indicating what will be the best investment. The one that has a higher EAC is the best option and may complement this information with the results of the LCC, and then the one which gets the lower value will be the better one.

5.3 Exploration Phase

In order to understand how to draw conclusions from the model, the modeling of another equipment, the 120/340 - Drilling Soilmec R725 CFA, is made. Subsequent to the completion of costs table, it is possible to get the results to be analyzed through the graph in figure 5 and table 3. The graph in Figure 5 permits to analyze the overall maintenance costs, as well as the accounting value and LCC, during the period under review.
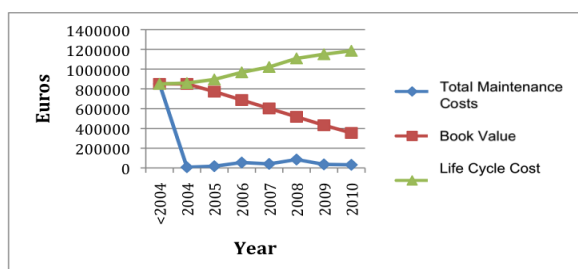

Figure 5 – Results for Drilling 120/340.

As can be seen, there is, over the years, a not very high, but increasing, value for the total maintenance costs, between 2004 and 2008, showing a slight decline in 2009. Since the total annual maintenance costs are identical, the LCC curve is linearly increasing, reflecting essentially in this case, the depreciation of equipment, what means that there are no significant reductions or increases in costs over the years.

Table 3 - Results for Drilling 120/340.

CCV =	1.184.822
VAL =	-306.160
CAE =	-41.472

With the analysis of Table 3 and as NPV is negative it is clear that the investment has not been profitable, since the updated income has not been able to cover the updated costs, to date, at current prices. However, as this analysis was only made for 12 years it is expected that, if the number of years increase, the NPV will be positive, because this type of equipment has a longer useful life.

It was found, when the collection of information from the ME-constructions was made, that not all the costs are being allocated to the equipments but just the maintenance, operation and depreciation ones. So, a simulation was done (case 2) incorporating other costs such as transportation to and from the yard, training, staging of equipment, stock, environmental and deactivation. The equipment that was used as an example was the 120 / 340 - R725 Soilmec Drilling CFA, and given the same number of years, 12 years, values for those costs were allocated to this equipment . The effect of this change is reflected in Table 4, and, as it is expected, a significant decrease in value of NPV and an increase in LCC is reported.

Table 4 - Results for Drilling 120/340.

	Case 1	Case 2
CCV =	1.184.822	1.409.102
VAL =	-306.160	-372.398
CAE =	-41.472	-50.444

It is of great importance that ME-Construction Company takes all these costs into account in a near future because they are high costs that are not being taken into account as equipment costs.

5.4 Deactivation Phase

In the last phase of maturation of the equipment after the equipment manager checks if there is any equipment that has completed its life time or is obsolete in the list view, there is a need to replace the equipment or to rebuild it. Managers have to be supported when taking their decisions. For that a model was created for the option "Repair or Replace" that allows three options. One is the reconstruction of existing equipment and the other two may be to choose between the purchase of two new models, equivalent to the old one. The tool mentioned above can also be used if the equipment suffers a serious accident and there is a need to see which option will

be more profitable for the company, to repair or deactivate and get a new one.

Table 5 - Rating Rebuild or Replace

Brand/model	Option to reconstruct	Option to replace	
	CATERPILLAR/ 14 H CCR	CATERPILLAR/ 14 M	KOMATSU
Year of manufacture	1997	2010	2010
Acquisitions cost	200 000€	290 000€	250 000€
Life (Years)	13	13	13
Accounting life (year)	13	13	13
Life (hours)	17 500	17 500	17 500
Investment value	145 463,00 €	290 000,00 €	250 000,00 €
Monthly value of mobilization)	1 982,15 €	1 982,15 €	1 982,15 €
Normal hourly	14,14 €	14,14 €	14,14 €
Residual value	50 000,00 €	75 000,00 €	55 000,00 €
Income (occupancy 70%) (annual)	35 684,68 €	35 684,68 €	35 684,68 €
Depreciation (annual)	11 189 €	22 308 €	19 231 €
LCC	363 009 €	468 262 €	302 505 €
NPV	-19 721 €	-89 487 €	-52 668 €
EAC	-2 550 €	-11 572 €	-6 811 €

NPV is negative in all options but the most advantageous is to reconstruct CATERPILLAR/14HCCR

In Table 5, once again, it is just needed to fill the first nine lines, and it is possible to compare which is the best option: to replace or to rebuild the equipment. The results that can be extracted from the output of the model are the LCC of the equipment, the annual depreciation and the NPV complemented by CAE to evaluate projects with different life spans.

Given the NPV analysis, we find in this simulation, that the most profitable option is to rebuild the existing equipment. The model automatically gives information about what is the best option based on data that was inserted into the table, and which is the most profitable when compared to its nearest rival. If the manager chooses not to select this option, he can analyze which of the two acquisition options has a higher positive NPV or less negative, because this is the best option to purchase. In this case it is possible to compare the projects through NPV because all of them have an expected life span of thirteen years that is equal to the accounting lifetime.

6.   Conclusions and Recommendations

In conclusion, the application of this model allows the manager to have tools that will help him to calculate and justify his decisions, and it is desirable that he can have, over the lifetime of the equipment, the full perception of the expenses and income.

This model was therefore developed with the aim of functioning as a decision support tool in the company. In this sense, and into the future, the company should develop a more sophisticated equipment expenses study of its equipments since there are expenses that are not being addressed.

Given the simplicity of this model it can be implemented with the systems already used in the company, which in this particular case is SAP, so, every year, automatically, costs and revenues are updated and allow projections of future costs based on past data, credible and real.

In a future development ME-Construction Company might aim not only to select their equipment at the lowest LCC and higher NPV / EAC, but also choose to release less greenhouse equipment in order to reduce the greenhouse effect, since this factor is not being contemplated, in order to have a brighter future for everyone.

References

[1] Ardit, D. and Messiha, H. M. (1999), Life cycle cost analysis (LCCA) in municipal organizations. *Journal of Infrastructure Systems*, Vol. 5 N. 1, pp. 1-10.

[2] Assis, R. and Julião J. (2009), *Gestão da Manutenção ou Gestão de Activos (custos ao longo do ciclo de Vida),* 10º Congresso de Manutenção, Figueira da Foz.

[3] Dangel, R. (1969), *Integrated Logistic Support (ILS) Implementation in the Naval Ship System Command*, ASE 6th annual technical symposium, pp. 1-25.

[4] Freire, C. (2006), *Custo do Ciclo de Vida em Sistemas de Bombeamento*, Bombas Grundfos Portugal, S.A., Lisboa.

[5] Hanafizadeh, P. and Latif, V. (2011), Robust net present value, *Mathematical and Computer Modelling*, Vol. 54, N. 1-2, pp. 233-242.

[6] Lindholm A. and Suomala P. (2004), *The Possibilities of Life Cycle Costing in Outsourcing Decision Making,* Frontiers of E-Business, pp. 226-241.

[7] Sinclair, D. R. (2010), Equivalent annual cost: a method for comparing the cost of multi-use medical devices, *Canadian Anesthesiologists Society*, Vol. 57, pp. 521–522.

[8] White, G. E. and Ostwld, P. F. (1976), Life cycle costing, *Management Accounting*, Vol. 57 N. 7, pp. 39-42.

[9] Woodward, D. (1997), Life Cycle Costing – theory, information acquisition and application. *International Journal of Project Management*, Vol. 15, N. 6, pp. 355-44.

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