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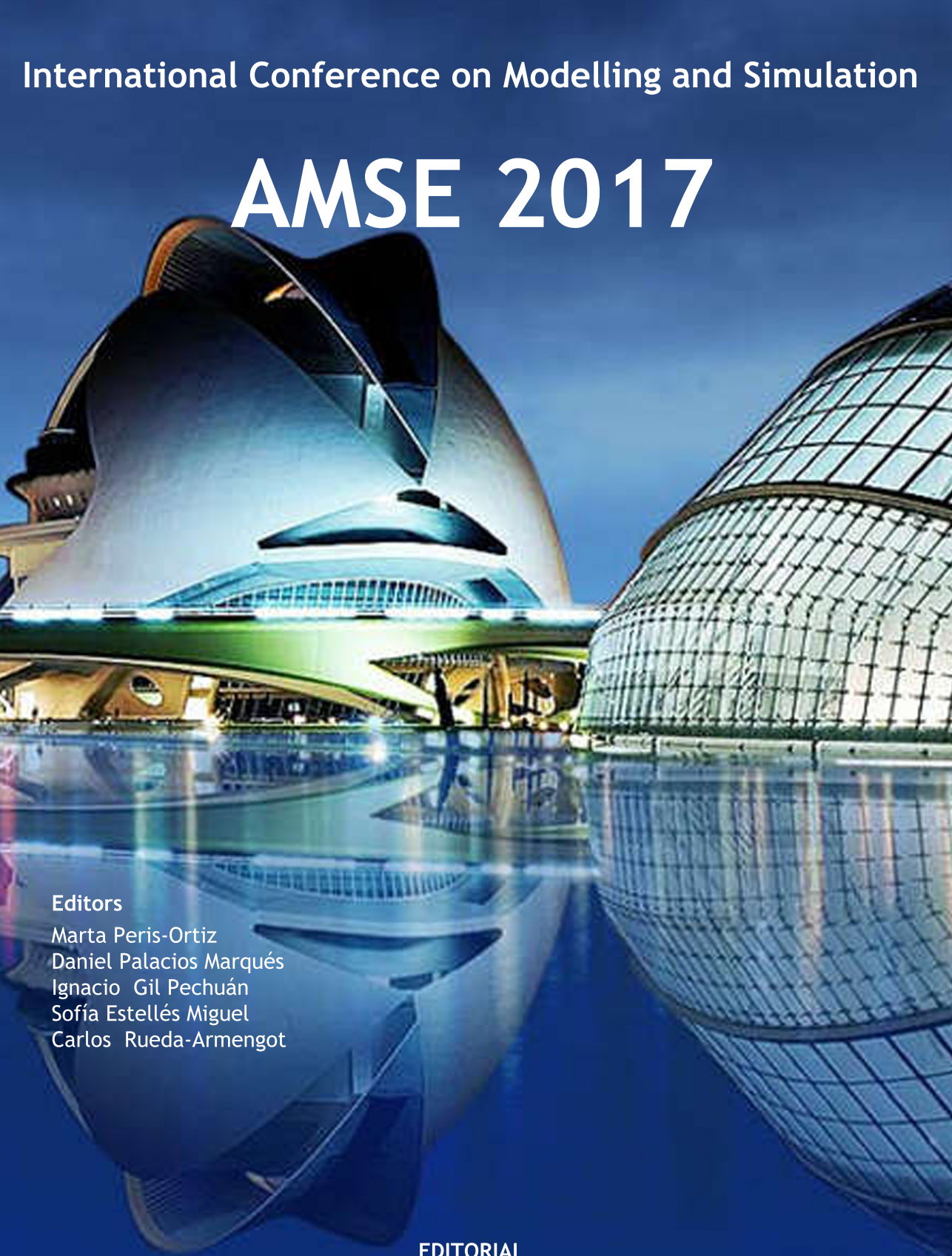
AMSE 2017



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EDITORIAL
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

AMSE 2017

International Conference on Modelling and Simulation

Valencia, 13th & 14th July 2017

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Congress UPV
International Conference on Modelling and Simulation AMSE 2017

The contents of this publication have been evaluated by the Scientific Committee

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Publisher

Editorial Universitat Politècnica de València, 2017
www.lalibreria.upv.es / Ref.: 6427_01_01_01

ISBN: 978-84-9048-605-4 (print version)

Print on-demand

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INDEX

Tax harmonization and incentives. A comparative study in the European Union

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Abstract

For decades, the European Union has faced the challenge of achieving tax harmonization to prevent tax avoidance practices as well as the consequent decapitalization of the affected territories.

This paper analyses the tax burden effectively paid by the 15 most representative countries of the European Union In the 2006-2014 time frame, with the aim to determine if there are significant differences between them which hinder the tax homogenization. To address this study, we have used the Statutory Tax Rate and Effective Tax Rate, since the latter is the indicator of choice to assess the paid tax burden. Likewise, the work was carried out from the incentives and disincentives perspective, both considered in net terms.

The study reveals that in the 2006-2014 period, the analysed European countries have used tax as a mechanism to approximate their respective tax burden and accordingly, achieve the tax harmonization. However and although it seems paradoxical, we understand that this solution does not guarantee the elimination of corporate offshoring and tax evasion, since each country has designed its own incentives policy in an individualized way, without coordinating this with the remaining countries. This situation means that companies continue to migrate to the territories which offer them the specific incentives which their particular investments require.

Keywords: *Effective tax rate, tax burden, incentives, tax harmonization.*

Introduction

The tax harmonization of the Corporate Income Tax is an issue which has recurrently concerned the governments of economically developed countries, since in the absence of taxation convergence, companies tend to move to territories with tax benefits and this

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offshoring, with its consequent tax evasion, has the undesirable effect of decapitalizing the affected territories.

However the reiterated attempts to harmonize the tax burden has frequently been unsuccessful in the past and this reality has been contemplated in numerous works which demonstrate the significant differences existing in the tax burden of the main countries. Thus, we can mention works about the tax burden in the USA (Kim et al. 2011; Dyreng et al. 2016); Australia (Richardson and Lanis, 2007) and in the Asian zone (Suzuki, 2014). Likewise, we can cite the works which compare the countries of different continents, among which we find the studies carried out on European and Non-European countries (Chennells & Griffith, 1997; Jacobs & Spengel, 2000) and even the ambitious works carried out on 50 and 83 countries (Abbas and Klemm, 2013; Chen and Mintz, 2011; respectively).

In the specific case of Europe, we may highlight the works by Buijink et al. (2002), Devereux et al. (2008), Overesch and Rincke (2011), Cuenca et al. (2013), Marques and Pinho (2014).

The European Union's (EU) concern to alleviate the tax evasion has intensified in recent years, which has motivated it to approve the Council Directive (EU) 2016/1164 of 12 July 2016 laying down rules against tax avoidance practices that directly affect the functioning of the internal market[1].

As its starting point, this recent Directive has used the BEPS Report (Base Erosion and Profit Shifting Project) from the Organisation for Economic Co-operation and Development (OECD)[2], which includes a set of recommendations to eliminate tax avoidance and in this way, achieve that the countries comply with their tax obligations in the country where they perform their activity.

This innovative perspective justifies our work and accordingly, we aim to obtain evidence about whether at present, they continue to support significant differences in the effective taxation of the EU, including Great Britain (UK); or on the other hand, if this territory has at least achieved a relative tax harmonization.

Hence to accomplish this objective, we shall analyse the effective tax rate of 15 European countries, since the effective tax rate is the most used indicator to measure the tax burden (Kaplan, 1975; Armstrong et al. 2012; Fairfield and Jorratt De Luis, 2016).

[1] This can be viewed in: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016L1164

[2] This can be viewed in: http://www.oecd-ilibrary.org/taxation/oecd-g20-base-erosion-and-profit-shifting-project_23132612

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However, the essential objective of this paper is to dimension the intrinsic nature of the difference existing between the Effective Tax Rate (ETR) and the Statutory Tax Rate (STR). This difference is derived based on the tax incentives and disincentives, implemented by the taxation policies designed by each of the member states of the EU.

According to the explained approaches, this work contributes to the literature by updating the studies about the evolution of the convergence, or where required, of the divergence existing in the tax burden derived from the different tax policies applied in the EU. Furthermore, it obtains evidence of the independent tax mechanisms of the STR which would cause the divergence. In addition, the number of selected countries, fifteen in our case, significantly exceeds that analysed by the majority of the prior studies on the comparative tax burden in European countries, which gives our work a much broader overview.

The selection of the ETR and the difference between the ETR and STR on which our empirical analysis is supported is based on a meticulous review of the literature and from the methodological perspective, the selection of the sample is justified to prevent biases which can lead to errors in the estimates, as well as validate the results.

Accordingly, we can highlight as the main result that the countries which maintain a STR above the average of the European STRs, offer higher incentives than the countries whose STR is situated below this average. Several of the latter countries even impose net disincentives, and all in order to approximate the ETRs and achieve the tax harmonization.

To address this task, the study has been organized as follows: first, we define the theoretical framework, carry out a review of the previous literature and pose the hypothesis to be tested; secondly, we set out the methodology and sample characteristics and explain the variables used; thirdly, we analyse the results; and finally, we show the main conclusions reached.

1. Literature review

The literature dedicated to comparing the tax burden among the territories has the essential aim to determine if there are different tax burden levels, which could affect the business location decisions. Among the most relevant studies, we can highlight those by Chennells and Griffith (1997); Jacobs and Spengel (2000); Devereux et al. (2002); Buijink et al. (2002); Overesch y Rincke (2011).

Thus, Chennells and Griffith (1997) compare the ETR and the STR of ten Non-European countries (Australia, Canada, USA and Japan) and European countries (France, Germany, Ireland, Italy, Spain and the UK) during the 1985-1994 period. These authors conclude that the countries which show the highest separation between both rates are Germany, Italy and Spain.

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Meanwhile, Jacobs and Spengel (2000) compare the ETR of the companies located in Germany, France, UK, Holland, and the USA during ten years. Their work shows the different levels of tax burden which exist by sectors inside the same country and by countries inside the same sector. Finally, they conclude that in the study period, the UK was the country with the lowest tax burden followed by the USA and Holland. In comparison, Germany and France are ranked as the countries with the highest ETR.

Devereux et al. (2002) analyse a sample of companies from EU and G-7 countries during the 80s and 90s decades; and they find that the STRs remain relatively stable . However, the STRs of the most profitable investments decline, which represents a form of tax competition to attract profitable investment projects to the territory and especially, Multinational companies.

In a strictly European scope, Overesch and Rincke (2011) studied the ETRs of 32 European countries in the 1983-2006 time frame, and concluded that for these countries, tax competition leads to a reduction in the tax rates.

Finally, the study by Buijink et al. (2002) analyses the fiscal policies of 15 EU member countries during the 1990-1996 period. The objective of this paper is focused on determining the existence of significant differences in the tax burden level represented by ETR. The conclusions show that tax incentives significantly differ between countries and cause a dispersion among the ETRs above the existing difference between the STRs.

2. Research design

2.1. Variables specification and research hypotheses

To obtain evidence about the existence of the harmonization or divergence of the tax burden among 15 EU member countries in the 2004-2014 period, we will use the variables of country and year.

With the aim to achieve this objective, we shall base the study on the ETR and STR. Likewise, we shall analyse the difference measured in absolute terms between the ETR and STR and in this way, we shall observe the absolute discrepancy (ABDIS) between both indicators.

Table 1 compiles the variables used in this work.

Table 1. Description of the study variables and calculation formula

VARIABLES	INITIALS	DESCRIPTION
1. Effective Tax Rate	ETR	$\frac{\text{Corporate income tax}}{\text{Pre} - \text{tax profit}}$
2. Statutory Tax Rate	STR	Percentage Value of Nominal Rate (provided by the European Commission)
3. ETR-STR Absolute Discrepancy	ABDIS	Effective Tax Rate – Statutory Tax Rate
4. Country	Country	(1-15)
5. Year	YEAR	(2006-2014)

Source: Own

The ETR selection is justified taking into account the numerous prior works which, since Kaplan (1975), have relied on this indicator since it is the one selected to analyse the tax burden (Fullerton, 1984; Wang, 1991; Buijink, 2002; Langli and Saudagaran; 2004; Armstrong et al. 2012; Chang et al. 2016.

The ETR used is defined as the quotient between the expense per Corporate Income Tax and the pre-tax profit (Jansen y Buijink, 2000); we shall compare it with the STR, as diverse authors have done in previous studies (Gupta & Newberry, 1997; Chen et al. 2016. This combination of variables complies with the recommendation by Omer et al. (1991), who indicate the convenience of using more than one measurement of taxation rates in the elaboration of the empirical study.

On the other hand, the ABDIS variable is especially useful to calibrate the different tax mechanisms of STR (Buijink et al. 2002), which means, measuring the level of deductions and permanent adjustments between the accounting and tax legislation. Table 2 shows the components of the independent tax mechanisms of the STR.

Table 2. Components of the independent tax mechanisms of STR

Independent tax mechanisms of STR	Incentive components	Deductions
		Permanent negative adjustments
	Disincentive components	Permanent positive adjustments

Source: Own

Evidently, it is important to interpret the sign which results from the difference between the ETR and STR. Hence, a negative value for the ABDIS variable indicates that the ETR is

lower than the STR as consequence of an incentive component, which means, due to deductions or permanent negative adjustments. On the other hand, a positive ABDIS value shows an ETR higher than the STR, since a disincentive component has occurred in the permanent positive adjustments. These potential results jointly with the generator elements are shown in Table 3.

Table 3. Interpretation of the sign of the ABDIS variable

Independent tax mechanisms of STR	Incentive components	Deductions
		Permanent negative adjustments
	Disincentive components	Permanent positive adjustments

Source: Own

Following the definition of our work and in coherence with our objective, we propose the hypotheses below:

H1. The average (median) of ETR is equal for all the European countries object of the study.

H2. The average (median) of the discrepancy, measured in absolute terms, between the ETR and STR (ABDIS), is equal for all the European countries object of the study.

2.2. Sample

We based our study on a sample of companies located in 15 Member countries of the EU which have relatively similar economic features. Accordingly, 13 countries were excluded which joined the EU after 2003; specifically, it discarded Cyprus, Slovenia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Czech Republic, Slovakia Republic, Bulgaria, Romania and Croatia.

Following the application of the suitable filters, a total of 777 companies comprised the sample. It involves listed companies which belong to different sectors, except the financial sector due to its special particularities, in line with other authors (Crabbe y Vandenbussche, 2009; Lisowsky 2010).

The time frame of the study is restricted to the period comprised from 2006 to 2014. This interval is of interest because it covers the years immediately prior to the major crisis up to the start of the economic recovery.

Table 4 shows the sample's composition broken down into countries and years, as well as the number of observations for each country and the weight of each number within the total observations.

Table 4. ETR Observations by countries and years

	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total observ. by country	%
Germany	158	156	150	145	158	150	148	144	145	1,354	21.7%
Austria	28	27	25	25	27	27	27	26	27	239	3.8%
Belgium	21	22	21	21	20	22	22	22	20	191	3.1%
Denmark	34	33	29	30	35	34	35	34	30	294	4.7%
Spain	26	26	25	27	26	24	22	19	25	220	3.5%
Finland	41	41	40	35	38	38	36	32	37	338	5.4%
France	87	91	87	82	90	87	88	84	87	783	12.5%
Greece	22	23	20	18	17	20	17	10	21	168	2.7%
Holland	28	28	24	25	28	27	24	27	24	235	3.8%
Ireland	18	20	20	18	20	19	20	19	18	172	2.8%
Italy	18	18	17	14	19	16	16	14	14	146	2.3%
Luxembourg	6	8	8	8	8	6	8	8	8	68	1.1%
Portugal	3	3	3	3	3	3	3	2	3	26	0.4%
United Kingdom	161	163	147	146	152	159	155	153	154	1,390	22.2%
Sweden	70	70	69	66	69	72	64	70	75	625	10.0%
TOTAL OBSERV. BY YEAR	721	729	685	663	710	704	685	664	688	6,249	100.0%
	11.5%	11.7%	11.0%	10.6%	11.4%	11.3%	11.0%	10.6%	11.0%	100.0%	

Source: Own

As can be seen, the sample is comprised by a total of 6,249 ETR observations. These observations have been calculated based on the Orbis financial data, marketed by Bureau van Dijk Electronic Publishing (BvD). On the other hand, the STR of the 15 countries analysed were extracted from the document: Taxation trends in the European Union, published by the European Commission[3].

2.3. Methodology Used

For each of the three variables, we shall first carry out the descriptive analysis with the main statistics.

Subsequently, we shall focus on the ETR and ABDIS (Absolute Discrepancy) variables and for each of them, we shall apply a parametric test to contrast the n means. Specifically, we will apply the analysis of the Anova variance. Next we shall focus on a non-parametric test by Kruskall Wallis to contrast the n medians. Both tests shall be carried out with the SPSS computer program.

In the case that the planned hypothesis cannot be fulfilled, and to assess the potential divergences, the study will be completed with a Robust Means Difference Contrast between the variables of each of the countries in relation to Germany; the country which we shall use as reference.

The succession of the described analysis will permit us to obtain evidence about the possible harmonization or where required, the divergence of effective taxes; as well as the features of the divergence in relation to the tax incentives or disincentives.

[3] http://ec.europa.eu/taxation_customs/business/economic-analysis-taxation/data-taxation_en

3. Results

3.1. Statutory Tax Rates presented by countries

Table 5 contains the main STR statistics during the 2006-2014 period. The countries with a STR above the European average are highlighted in grey.

Table 5. STR statistics by countries for the 2006-2014 period

	Obs.	Average	Median	Typical D.	Maximum	Minimum
Germany	1354	0.3217	0.3020	0.0359	0.3870	0.3020
Austria	239	0.2500	0.2500	0.0000	0.2500	0.2500
Belgium	191	0.3400	0.3400	0.0000	0.3400	0.3400
Denmark	294	0.2530	0.2500	0.0099	0.2800	0.2450
Spain	220	0.3089	0.3000	0.0171	0.3500	0.3000
Finland	338	0.2504	0.2600	0.0187	0.2600	0.2000
France	783	0.3517	0.3440	0.0122	0.3800	0.3440
Greece	168	0.2451	0.2500	0.0277	0.2000	0.2000
Holland	235	0.2575	0.2550	0.0141	0.2960	0.2500
Ireland	172	0.1250	0.1250	0.0000	0.1250	0.1250
Italy	146	0.3285	0.3140	0.0255	0.3730	0.3140
Luxembourg	68	0.2911	0.2920	0.0040	0.2960	0.2860
Portugal	26	0.2873	0.2950	0.0211	0.3150	0.2650
United Kingdom	1390	0.2668	0.2800	0.2100	0.3000	0.2100
Sweden	625	0.2587	0.2630	0.0225	0.2800	0.2200
EU-15 Average	**6249**	**0.2870**	**0.3000**	**0.0523**	**0.3870**	**0.1250**

Source: Own

The results show differences between the STR of the different EU countries. The European average stood at 28.70% for the period as a whole, and compared with this mean, there were seven countries above it: France, Belgium, Italy, Germany, Spain, Luxembourg and Portugal.

On the other hand, there were eight countries below the average: United Kingdom, Sweden, Holland, Denmark, Finland, Austria, Greece and Ireland; where the latter country showed the lowest STR (12.5%). On the opposite end, France had the highest STR (35.17%).

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3.2. Effective Tax Rate

Table 6 shows the results of the statistics for the ETR variable during the 2006-2014 period. The countries with an ETR above the European average are highlighted in grey.

Table 6. Descriptive ETR statistics by countries for the 2006-2014 period

	Obs.	Average	Median	Typical D.	Maximum	Minimum
Germany	1354	0.2865	0.2954	0.1007	0.5906	0.0000
Austria	239	0.2338	0.2375	0.1001	0.5914	0.0054
Belgium	191	0.2306	0.2437	0.1079	0.5543	0.0000
Denmark	294	0.2603	0.2572	0.0970	0.5848	0.0000
Spain	220	0.2385	0.2488	0.1054	0.5469	0.0036
Finland	338	0.2307	0.2440	0.0886	0.4664	0.0000
France	783	0.3039	0.3068	0.0881	0.5972	0.0163
Greece	168	0.2533	0.2533	0.1214	0.5745	0.0000
Holland	235	0.2172	0.2294	0.0986	0.5975	0.0027
Ireland	172	0.1903	0.1770	0.0954	0.5989	0.0058
Italy	146	0.3398	0.3491	0.1135	0.5850	0.0379
Luxembourg	68	0.2596	0.2631	0.0996	0.5966	0.0141
Portugal	26	0.2311	0.1248	0.1043	0.4359	0.0080
United Kingdom	1390	0.2530	0.2627	0.0000	0.5842	0.0000
Sweden	625	0.2556	0.2658	0.0863	0.5855	0.0000
UE-15 Average	6249	0.2631	0.2709	0.1018	0.5989	0.0000

Source: Own

As can be seen, the ETR of the different countries also reveal differences. The average European ETR stands at 26.31%, comparatively lower than the average European STR (28.70%). This difference between the averages of both variables reveals the existence of independent net tax incentive mechanisms.

Likewise, we observe that there are only three countries with an ETR above the average, where Italy is the country which has the highest average ETR (33.98%), followed by France (30.39%) and Germany (26.85%). On the other hand, Ireland is shown as the country with the lowest tax burden (19.03%).

3.2.1. Anova analysis-variance for the ETR

Table 7 contains the results of the Anova analysis for the ETR.

Table 7. Anova analysis for the ETR by countries for the 2006-2014 period

Sample: 1 1396 **Observations: 1396**			
Method	gl	Value	Probability
Anova F-test	(14, 6315)	55.23249	0.0000
Welch F-test*	(14, 846.977)	54.04536	0.0000
Variation source	gl	Sum squared	Mean squared
Between	14	9.570324	0.683595
Intra	6315	78.15871	0.012377
Total	6329	87.72903	0.013861

Source: Own

The analysis of the variance corroborates the result obtained in the descriptive study. The Anova is fulfilled with a Value of 55.23, which corresponds to a significance level of 0% or, alternatively, with a confidence level of 100%.

Consequently, it has been found that the average ETRs are significantly different among the EU countries for the 2004-2014 period and hence, the first hypothesis is rejected.

3.2.2. Kruskall-Wallis Test for the ETR

The results obtained in the Kruskall-Wallis Test for the ETR are shown in Table 8.

Table 8. Kruskall-Wallis Test for the ETR by countries for the 2006-2014 period

Sample: 1 1396 **Observations: 1396**			
Method	gl	Value	Probability
Chi-Square	14	617.7386	0.0000
Kruskall-Wallis	14	768.1853	0.0000
Van der Waerden	14	741.3179	0.0000

Source: Own

The Kruskall-Wallis test corroborates the Anova conclusions and the descriptive analysis, with a Value of 668.18 and a significance level of 0%. These results reinforce the rejection of the first hypothesis, hence affirming the significant difference between the median ETRs of the European countries object of the study.

3.2.3. Contrast the Robust Means Difference for the ETR

Both the Anova analysis and the Kruskall-Wallis test reject the equality hypothesis of the ETRs, however they do not provide information about which countries are the ones which cause this divergence. For this reason, we propose a Robust Means Difference Contrast of each country in relation to Germany with the aim to discriminate the countries which show significant differences.

Table 9. Robust Means Constrast by pairs (in relation to Germany) for the ETR by countries for the 2006-2014 period

Germany	**28.65%**	**Average**
Austria	**23.38%**	**Average**
	***-5.27%	**Differences**
Belgium	**23.06%**	**Average**
	***-5.60%	**Differences**
Denmark	**26.03%**	**Average**
	***-2.62%	**Differences**
Spain	**23.85%**	**Average**
	***-4.80%	**Differences**
Finland	**23.07%**	**Average**
	***-5.58%	**Differences**
France	**30.39%**	**Average**
	***1.74%	**Differences**
Greece	**25.33%**	**Average**
	***-3.32%	**Differences**
Holland	**21.72%**	**Average**
	***-6.94%	**Differences**
Ireland	**19.03%**	**Average**
	***-9.62%	**Differences**
Italy	**33.98%**	**Average**
	***5.33%	**Differences**
Luxembourg	**25.96%**	**Average**
	***-2.69%	**Differences**
Portugal	**23.11%**	**Average**
	***-5.54%	**Differences**
United Kingdom	**25.30%**	**Average**
	***-3.35%	**Differences**
Sweden	**25.56%**	**Average**
	***-3.09%	**Differences**

Significance level of 1%, 5% and 10% with ***, **, * respectively

Source: Own

The results, compiled in Table 8, show how all the countries present significant differences in their respective average ETR in relation to Germany. The significance level is very high, practically below 1% in all of them and only Luxembourg has a significance level below 5%.

These results confirm and complete the data obtained in the previous analyses.

3.3. Efective-Statutory Absolute Discrepancy (ABDIS)

Table 10 presents the results, with groupings by countries, of the statistics for the ABDIS variable during the 2006-2014 period. The countries with net tax disincentives have been highlighted in blue; while the countries with net tax incentives higher or lower than the European average are respectively shown in white and grey.

The average ABDIS presents a negative result for 11 countries, as well as for the 15 countries considered in a joint way. Specifically for Europe as a whole, the average ETR stood at 2.39% below the average STR.

Taking into account that the ABDIS has been proposed as the difference between the ETR and STR, a negative value of the variable showed evidence of a STR below the STR and consequently, several incentives higher than the disincentives. Thus the descriptive analysis shows the existence of net tax incentives in the majority of the analysed territory.

Among the countries which have net tax incentives, we highlight Belgium, with a lower ETR of 11% in relation to to its STR. On the other hand, Sweden is shown as the country which has the lowest net tax incentives, with an ETR below its STR at only 0.31%.

In reference to the four countries which present net disincentive, we can highlight the case of Ireland, with an average ABDIS of 6.53%. It is worth mentioning that Ireland, with the smallest STR in Europe (12.5%), applies tax policies aimed at increasing this minimum STR, and hence the net disincentives cause its ETR to be 6.53% higher than its STR. The positive sign of the Irish ABDIS is caused by the permanent tax adjustments higher than the deductible adjustments and the deductions. However despite this, Ireland's ETR of 19% continues to be the minimum rate in the EU.

Table 11 simultaneously shows the means obtained in the descriptive analysis for the STR, ABDIS and ETR variables; with the a ranking criteria from lowest to highest for each one of them.

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Table 10. Descriptive ABDIS statistics by countries for the 2006-2014 period

	Obs.	Mean	Median	Std. Desv	Maximum	Minimum
Germany	1354	-0.0352	-0.0194	0.1036	0.2886	-0.3836
Austria	239	-0.0162	-0.0125	0.1001	0.3414	-0.2446
Belgium	191	-0.1094	-0.0963	0.1079	0.2143	-0.3400
Denmark	294	0.0073	0.0022	0.0970	0.3348	-0.2500
Spain	220	-0.0703	-0.0594	0.1073	0.2469	-0.3196
Finland	338	-0.0197	-0.0059	0.0893	0.2214	-0.2503
France	783	-0.0478	-0.0438	0.0881	0.2508	-0.3438
Greece	168	0.0083	0.0082	0.1239	-0.2500	-0.2500
Holland	235	-0.0403	-0.0273	0.0988	0.3425	-0.2671
Ireland	172	0.0653	0.0520	0.0954	0.4739	-0.1192
Italy	146	0.0113	0.0234	0.1127	0.2456	-0.2761
Luxembourg	68	-0.0314	-0.0240	0.0992	0.3086	-0.2779
Portugal	26	-0.0562	-0.1702	0.1046	0.1709	-0.2706
United Kingdom	1390	-0.0138	-0.0079	-0.3000	0.3639	-0.3000
Sweden	625	-0.0031	0.0029	0.0874	0.3408	-0.2800
UE-15 Average	**6249**	**-0.0239**	**-0.0137**	**0.1024**	**0.4739**	**-0.3836**

Source: Own

Table 11. Ranked mean of the ADBIS, ETR and STR variables by countries for the 2006-2014 period

	STR		ABDIS		ETR		EXPLANATORY OBSERVATIONS OF THE MOST OUTSTANDING POSITION IN THE ETR RANKING
-	IR	0.125	IR	0.065	IR	0.190	Minimum ETR explained by the minimum STR in the EU (despite having the maximum disincentives in the EU)
	GR	0.245	IT	0.011	HO	0.217	Very low ETR explained by the STR below the average, to which incentives are added higher than the average (dissident conduct)
	AU	0.250	GR	0.008	BE	0.231	Very low ETR explained by the maximum incentives in the EU (despite having the 2nd highest STR in the EU)
	FI	0.250	DE	0.007	FI	0.231	Notable: Finland is the ABDIS median
	DE	0.253	SW	-0.003	PO	0.231	ETR below average explained by the 3rd highest incentives in the EU (despite having a STR above the average)+
	HO	0.257	UK	-0.014	AU	0.234	
	SW	0 259	AU	-0.016	SP	0.239	ETR below average explained by the 2nd highest incentives in the EU (despite having a STR above the average)
	UK	0.267	FI	-0.020	UK	0.253	Notable: The UK is the median for the ETR and STR
	PO	0.287	LU	-0.031	GR	0.253	
	LU	0.291	GE	-0.035	SW	0.256	Notable: Luxembourg with practically no incentives or disincentives (very close ETR and STR)
	SP	0.309	HO	-0.040	LU	0.260	
	GE	0.322	FR	-0.048	DE	0.260	
	IT	0.329	PO	-0.056	GE	0.287	Very high ETR explained by the 4th highest STR in the EU
	BE	0.340	SP	-0.070	FR	0.304	Very high ETR explained by the maximum STR in the EU
+	FR	0.352	BE	-0.109	IT	0.340	Maximum ETR explained by the 3rd highest STR in the EU, to which tax disincentives are added (dissident conduct)

EU mean marked by:
Blue tones: Countries with ETRs below the average
Light purple tones: Countries with ETRs above the average

Source: Own

As can be seen, the most frequent scenario is the correction of the STR by independent tax mechanisms, so that the STR above the European average is combined with high tax incentives, also above the average; and a STR below the average is combined with scarce tax incentives, below the average or with disincentives. The oval symbol indicates the countries with dissident conducts which do not fit inside this diagram: Holland and Italy.

3.3.1. Analysis of Variance – Anova for the ABDIS

The results of the Anova analysis for the contrast of the means of the ABDIS variable by countries are shown in Table 12.

Table 12. Anova analysis for the ADBIS by countries for the 2006-2014 period

Sample: 1 1396 Observations: 1396			
Method	gl	Value	Probability
Anova F-test	(14, 6321)	34.62204	0.0000
Welch F-test*	(14, 844,869)	32.69806	0.0000
Variation source	gl	Sum squared	Mean squared
Between	14	4.858926	0.347066
Intra	6321	63.36441	0.010024
Total	**6335**	**68.22334**	**0.010769**

Source: Own

Again, the Anova analysis corroborates the results provided by the ABDIS descriptive study, with a Value of 34.62 and a significance level of 0%. Hence, the second hypothesis is rejected in relation to the equality of the average ABDIS among all the European countries of this study.

3.3.2. Kruskall-Wallis Test for the ABDIS

Table 13 below contains the results obtained in the Kruskall-Wallis test for the medians contrast of the period corresponding to the ABDIS variable by countries.

Table 13. Kruskall-Wallis test for the ADBIS by countries for the 2006-2014 period

Sample: 1 1396 Observations: 1396			
Method	gl	Value	Probability
Med. Chi-square	14	435.3033	0.0000
Kruskall-Wallis	14	492.6613	0.0000
Van der Waerden	14	491.1813	0.0000

Source: Own

The Kruskall-Wallis test confirms the previously obtained results, with a Value of 492.66 and a significance level of 0%. Consequently, the second hypothesis is rejected in relation to the equality of the ABDIS mean among all the European countries object of this study.

3.3.3. Contrast of the Robust Means Difference

Table 14. Robust Means Contrast by pairs (in relation to Germany) for the ADBIS by countries for the 2006-2014 period

Germany	-3.52%	Average
Austria	-1.62%	Average
	***1.90%	Differences
Belgium	-10.94%	Average
	***-7.43%	Differences
Denmark	0.73%	Average
	***4.25%	Differences
Spain	-7.03%	Average
	***-3.51%	Differences
Finland	-1.97%	Average
	***1.55%	Differences
France	-4.78%	Average
	***-1.26%	Differences
Greece	0.83%	Average
	***4.34%	Differences
Holland	-4.03%	Average
	-0.51%	Differences
Ireland	6.53%	Average
	***10.05%	Differences
Italy	-1.13%	Average
	***2.39%	Differences
Luxembourg	-3.14%	Average
	0.37%	Differences
Portugal	-5.62%	Average
	-2.10%	Differences
United Kingdom	-1.38%	Average
	***2.14%	Differences
Sweden	-0.31%	Average
	***3.21%	Differences

Significance level of 1%, 5% and 10% with ***, **, * respectively

Source: Own

Finally, Table 14 presents the results obtained in the Robust Means Difference Contrast for the ABDIS variable of the different countries in relation to Germany. The countries are shown highlighted in grey which show significant differences in comparison with Germany.

The analysis confirms the conclusions provided by the descriptive analysis. The results indicate that the average level of the period for the ABDIS variable in Germany is significantly different from the majority of the countries. Eleven countries revealed significant differences compared with Germany, nine of them with a significance level of 1% and two with a level of 5%. Only three countries did not show significant differences: Holland, Luxembourg and Portugal.

4. Conclusions

4.1. Conclusions about the ETR

The countries' concern to fight against tax evasion has resulted in the recently approved Council Directive (EU) 2016/1164 of 12 July 2016 laying down rules against tax avoidance practices that directly affect the functioning of the internal market. In line with other previous studies, this paper shows the EU's interest in harmonizing the tax burden paid by the member states, and aims to show if the tax policies addressed during the period comprised between the years 2006 and 2014 have resulted in a tax convergence which prevents tax evasion to other territories.

For this purpose, we have compared the ETR paid by 6,249 companies corresponding to the 15 EU countries which have similar economic characteristics.

After carrying out the Anova analysis and the Kruskall-Wallis Test, jointly with the Robust Means Contrast, we observe that the average ETR of each of the countries in relation to the average of Germany (country used as reference, an average ETR of 26.85%), show significant differences. In this context, Italy is the country which has the highest tax burden, an average ETR of 33.98%; while Ireland is shown on the opposite side with a tax burden represented in an ETR of 19.03%.

These results, which reveal the lack of tax harmonization in the EU countries during the 2006-2014 period, are in line with those obtained by Buijink et al. (2002), Abbas and Klemm (2013), Marques and Pinho (2014).

4.2. Conclusions about the difference between the ETR and STR

In order to analyse the characteristics of the divergences existing between the ETR which hinder the harmonization of the EU countries, we have defined the ABDIS variable as the difference, measured in absolute terms between the ETR and STR (ABDIS). When these differences are different from zero, this is due to the existence of net incentives. Specifically, this is due to deductions and permanent positive or negative adjustments.

This analysis is very interesting in our opinion because the structure of a country's tax incentives depend on the taxation policy which is designed, and in the EU, these policies must pursue harmonization to prevent the corporate offshoring and tax avoidance.

To study the ABDIS, we proceeded in the same way as in the ETR case. The results show that the countries which show a STR above the European average, situated at 28.70%, are the ones which offer the highest tax incentives, with the exception of Italy in order to compensate the higher taxation.

On the other hand, the countries whose STR is lower than the European average are the ones which have the lowest incentives and even tax disincentives, with the exception of Holland; with the aim to rectify the lower taxation. Precisely Holland, despite possessing a STR of 25.75%, below the European average, has an ETR of 21.72% and consequently, an ABDIS of -4.03%; where it is the country which is closest to the tax burden of Ireland, whose ETR amounts to 19.03%.

For a better understanding, Table 15 shows the average ETR ranking of each country in relation to the European average as well as the intensity of their net tax incentives.

Table 15. Incentives and ETR ranking of each country in relation to the European average, 2006-2014

Tax policy	Country	Average STR	Average ABDIS	Exception
	France	0.3517	-0.0478	
Higher	Belgium	0.3400	-0.1094	
net	Italy	0.3285	0.0113	Italy
incentives	Germany	0.3217	-0.0352	
	Spain	0.3089	-0.0703	
	Luxembourg	0.2911	-0.0314	
	Portugal	0.2873	-0.0562	
	EU-15 Average	**0.2870**		
	United Kingdom	0.2668	-0.0138	
	Sweden	0.2587	-0.0031	
Lower	Holland	0.2575	-0.0403	Holland
net	Denmark	0.2530	0.0073	
incentives or	Finland	0.2504	-0.0197	
disincentives	Austria	0.2500	-0.0162	
	Greece	0.2451	0.0083	
	Ireland	0.1250	0.0653	

Source: Own

This relation between the STR dimension and the intensity of the incentives shown in this work, for the 2006-2014 time frame clearly shows the efforts by the European countries to approximate the effective tax burden. This conclusion differs from that obtained by Buijink et al. (2002) for the 1990-1996 period, stating that the relation between the STR and incentives is erratic and does not have the effect of approximating the tax burden in the EU countries.

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However based on our findings, we understand that using the incentives and disincentives as a mechanism to achieve the tax harmonization does not represent a sufficient measure to achieve this objective if the countries do not agree to align their fiscal policies in the incentives issue. In other words, if each country applies an individual incentives policy, companies will continue to migrate to the territories which offer them specific incentives which are suitable for their specific activity or investment.

Thus in our opinion, the European countries should propose approximating their tax burden based on the harmonization and their STR as well as the incentives policies or alternatively, they should synchronize their STR with the incentives which they offer to achieve a common ETR.

From this perspective, we believe that this paper may be of interest for the governments of the respective European countries, in a way that helps them to complete the information which they require to design their tax policies focused on achieving the desired harmonization and finally accomplish the elimination of tax shelters and tax evasion.

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Estimates validation in a two-factor stochastic valuation model

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Abstract

The uncertainty the financial derivatives are subject to points to the importance of having valuation models that are as accurate and parsimonious as possible. Given the myriad of available models, an exploratory validation criterion is necessary to aid the analyst decision-making process. We use a canonical oil future valuation model, namely, the Gibson-Schwartz Model (1990). The work implements it to validate its parameter estimates in order to explore its accuracy. To do this we develop a case-based validation procedure using a STATA code. This work concludes that the model is satisfactory given its parsimonious nature, but there is room for improvement in considering some contesting models.

Keywords: *M*ulti-factorial model, stochastic process, financial derivatives valuation, commodities futures.

Introduction

When assesing reduced form models for the valuation of a financial instrument the analysts are interested in at least two things. Firstly, in proposing an instrument whose price is explained by factors that account for the most important stylized facts that may be observed. Then, this models has to adhere to the lex parsimoniae principle. This means that, if the chosen model is to be applied in a meaningful way, it need not be so complex that it becomes intractable. We take the commodities market, in particular, an oil futures valuation model. This work deals with the question of how can one know if a certain model readily captures certain relevant stylized facts of the modelled process.

Two types of criteria may be forwarded to answer this question. The first one would be to take an a priori criterion with respect to the estimation process and ask whether the theoretical properties of the proposed process are similar to the empirical properties of the empirical process. For example, if we are modelling the price of a stock with a Brownian Motion in the Black & Scholes fashion then, knowing that said process is non-stationary, it would be convenient to perform a unit root test on the underlying time series to see if the empirical and

theoretical processes share this property. This has the shortcoming that it completely ignores whether the estimation of the model has been correctly performed. On a related issue, if the estimation process involves synthetic series, this may be incorrectly generated.

A different approach that avoids this problems would be to adopt an a posteriori criterion, this is, to evaluate the relevance of the model after the estimation procedure has taken place. This is in time, divided into two approaches. The analyst might follow a forecast error criterion when choosing between different models, or it may aim at the stability of the parameters' estimates over different periods of time. The former has the disadvantage of encouraging overparametrization of the model (Domingos, 2000), consequently this needs to be taken into account. The latter has the advantage of providing qualitative information about which parameter is not being correctly modelled and, consequently, which model to consider from there.

This work argues that although the importance of forecasting error in choosing between different valuation models cannot be stressed enough. There is qualitative information that can be conveyed through the estimation of the same process during different timeframes rather than different processes on one time window and how this information could be extracted on a stochastic valuation model. This is done in the following two sections. The first one will present one model of the kind, proposed for valuing oil futures (Gibson, 1990), and how to estimate and calibrate its parameters over a one-year time window. Next section repeats the procedure over a rolling window and discusses how the estimates change over time. Finally, the authors give a conclusion and propose future research.

1. The model, presentation and estimation strategy

The model considers a derivative, $F(S, \delta, \tau)$, with two sources of uncertainty that describe the dual role of crude oil (which is both a financial and physical asset), namely, its spot price, S, and the flow of funds generated by it being a storable good, its net convinience yield, δ.

The dynamics of S, and δ are represented by a set of two stochastic differential equations with correlated increments in the following manner:

$$\begin{cases} dS = \mu S dt + \sigma_1 S dw_1 \\ d\delta = k(\alpha - \delta)dt + \sigma_2 dw_2 \\ dw_1 dw_2 = \rho \sigma_1 \sigma_2 dt \end{cases} \quad \textbf{(1)}$$

Where $\mu, \alpha, k, \sigma_1, \sigma_2$, and ρ are constants. In particular, μ represent the rate of growth of the spot price, α the convinience yield long term average value, k the velocity of convergence towards α, σ_1 and σ_2 the volatilities of the spot price and the convinience yield respectively, and ρ the correlation between both standard Brownian increments, dw_1 and dw_2.

By application of Ito's Lemma to $F(S, \delta, \tau)$ we get:

$$dF = (-1)\frac{\partial F}{\partial \tau}dt + \frac{\partial F}{\partial \delta}d\delta + \frac{\partial F}{\partial S}dS + \frac{1}{2}\frac{\partial^2 F}{\partial \tau^2}(dt)^2 + \frac{\partial^2 F}{\partial \delta^2}(d\delta)^2 + \\ + \frac{1}{2}\frac{\partial^2 F}{\partial S^2}(dS)^2 + \frac{\partial^2 F}{\partial S \partial \delta}d\delta dS - \frac{\partial^2 F}{\partial \tau \partial S}dSdt - \frac{\partial^2 F}{\partial \tau \partial \delta}d\delta dt \quad \textbf{(2)}$$

Noting that $(d\tau)^2, d\tau dS$, and $d\delta d\tau$ decrease much faster than dt. Replacing all differentials in the prior equation we have:

$$dF = \left\{-F_\tau + \frac{1}{2}F_{SS}\sigma_1^2 S^2 + \frac{1}{2}F_{\delta\delta}\sigma_2^2 + S\rho\sigma_1\sigma_2 F_{S\delta} + F_s\mu S + F_\delta[k(\alpha - \delta)]\right\}dt \\ + \sigma_1 S F_S dz_1 + \sigma_2 F_\delta dz_2 \quad \textbf{(3)}$$

Where F_{ij} stands for $\partial^2 F/\partial i\, \partial j$. We consider that under the non-arbitrage principle, and in a perfect market setting (most notably, where information is perfect and complete). Then the instantaneous yield of the future must equal the instantaneous risk free interest rate, plus the instantaneous yields of the two sources of risk that the future is subject to (i.e. spot and convinience yield risk). Weighted by two prices of risk, this means that:

$$\mu_F = r + \lambda' \frac{SF_s\sigma_1}{F} + \lambda\frac{F_\delta\sigma_2}{F} \quad \textbf{(4)}$$

Which yields:

$$\frac{1}{2}F_{SS}\sigma_1^2 S^2 + \frac{1}{2}F_{\delta\delta}\sigma_2^2 + S\rho\sigma_1\sigma_2 F_{S\delta} + F_s(r - \delta)S + \\ + F_\delta(k(\alpha - \delta) - \lambda\sigma_2) - F_\tau - rF = 0 \quad \textbf{(5)}$$

A closed form solution to this equation is given in (Carmona, 2004). Under martingale measure, the price of a future must be:

$$F_t = S_t \cdot \exp\left\{\tau\left(-\alpha + \frac{1}{k}(\sigma_2\lambda - \sigma_2\sigma_1\rho) + \frac{1}{2}\left(\frac{1}{k}\right)^2\sigma_2^2\right)\right. \\ -\frac{1}{k}(1-e^{-k\tau})\left(\delta - \alpha + \frac{1}{k}(\sigma_2\lambda - \sigma_2\sigma_1\rho) + \left(\frac{1}{k}\right)^2\sigma_2^2\right) \\ \left.+\frac{1}{2}\left(\frac{1}{k}\right)^2\frac{\sigma_2^2}{2k}(1-e^{-k\tau})^2\right\} \quad \textbf{(6)}$$

So one has a function F_t of six parameters to be estimated $\alpha, k, \sigma_1, \sigma_2, \rho,$ and λ the contemporaneous convinience yield, and spot price. We follow the estimation procedure as a slight variation of (Gibson, 1990), see (Lautier, 2002) and (Jafarizadeh et al, 2012), for alternative estimation strategies.

The data consists of the daily price of futures on the West Texas Intermediate reference basket (WTI), as well as its associated spot price, between the January 2 nd, 1986 and August 8th, 2016[4]. For the risk free interest rate, we used the implicit yield of a 3 month US Federal treasury bond[5].

First, one needs to generate the synthetic convenience yield series, this can be done by re-arranging (and annualizing) the known relation between a future price, the risk free interest rate, and its maturity. An argument for this kind of derivation is given in Geman et al. (2009). We have:

$$F(S_t, T) = F_{t,T} = S_t e^{(r-\delta_{t,T})} \quad \textbf{(7)}$$

That turns into:

$$\delta_{t,T} = r - 12\ln\left(\frac{S_t}{F_{t,T}}\right) \quad \textbf{(8)}$$

A second step in the process is to estimate the volatilities σ_1 and σ_2 as the annualized sample standard deviation of the spot and convinience yield series.

[4] Available at http://www.eia.gov/petroleum/data.cfm

[5] Available at https://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=billrates

The third step is to estimate a seemingly unrelated regression model, which proposes the model:

$$\begin{cases} \Delta\delta_t = \alpha k + k\delta_{t-1} + e_t \\ \ln\left(\frac{S_t}{S_{t-1}}\right) = a + bln\left(\frac{S_{t-1}}{S_{t-2}}\right) + \epsilon_t \end{cases} \quad \textbf{(9)}$$

Allowing for the case that $\mathrm{Cov}(e_t, \epsilon_t) \neq 0$. The first equation is a discretized version of (eq. 1), while the second equation exploits the fact that a Brownian motion has independent increments, so one intends that $a = b = 0$, in order to capture only noise (i.e. $\mathrm{Cov}(\Delta\delta_t, \ln\left(\frac{S_t}{S_{t-1}}\right)) = \mathrm{Cov}(e_t, \epsilon_t)$), so that the estimate $\hat{\rho} = \frac{\mathrm{Cov}(e_t, \epsilon_t)}{\hat{\sigma}_1 \hat{\sigma}_2}$ approximates the expression: $\rho dt = \frac{dz_1 dz_2}{\sigma_1 \sigma_2}$.

Once $\alpha, \sigma_1, \sigma_2, k$, and ρ have been correctly estimated, λ can be calibrated so as to minimize the deviation between the theoretical price of the future and its observed value in the market:

$$Min_\lambda error = |F_t - F_t^*(\alpha, k, \sigma_1, \sigma_2, \rho, \lambda)| \quad \textbf{(10)}$$

Where F_t is observed in the market, and $F_t^*(\alpha, k, \sigma_1, \sigma_2, \rho, \lambda)$ is calculated by replacing the parameter's values on (eq 10). There is a certain amount of leeway on the choice of the error measure to be minimized[6].

The last remaining task to be performed for the model to be operational is to choose how many registers of the available data are to be used in the estimation procedure. If we choose too large a window, e.g. all available data, one risks to estimate the parameters over irrelevant information, which would yield inaccurate results. On the other hand, if one chooses a window that is too small, e.g. the last five data points of the series, the results would be biased as one may take a particular, short-lived, idiosyncratic shock as if it were relevant information. We have chosen one year trading (the last 254 registers) as is customary in this kind of application.

[6] We have chosen λ so as to minimize the mean absolute error, but choosing the mean squared error or a more sophisticated error measure can be argued to be more convenient.

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Under this specification, we arrived at the following estimates:

Table 1. Specifications and estimates

$\hat{\alpha}$	-0,00319
$\hat{k}$	-1,1213
$\widehat{\sigma_1}$	0,20266738
$\widehat{\sigma_2}$	0,005679
$\hat{\rho}$	-0,9562
$\bar{\lambda}$	2,183107

Source: Own

Now we are interested in whether this values are (relatively) stable across time, and, if not, whether they seem to be evolving randomly, or if they have a visible trend. We argue that this kind of analysis yields qualitative information on where, if, the model is failing (what assumption of the model is too simplistic), while giving insight on how this particular market works. For example, if one is to find a visible trend in one of the parameters, then modeling said parameter as a constant is unrealistic. In the next section, we exemplify how this type of analysis might be performed.

2. Validation of Estimates

We propose to repeat the previous estimation procedure of the parameter's values using a rolling window of fixed width (1 year trading). This process is easily performed using the econometric STATA 13 software by means of a roll function[7]. We focused on the parameters $\alpha, \sigma_1, \sigma_2,$ and k as they have proven to be interesting examples from the theoretical point of view, while disregarding the parameters λ, which is not estimated, and ρ, which has no clear causal interpretation and have been divided into cases accordingly as follows:

2.1. Case 1: k, the velocity of convergence of δ towards α seems to be correctly modelled

As can be seen from figure 1, although subject to considerable fluctuations, the estimates of k seems to gravitate over a constant long-run velocity. It has no visible trend nor its variance seem to be a function of time. This is exactly what hopes to find when estimating a constant subject to random disturbances, hence, one can safely assume that the assumption of constant velocity of convergence is reasonable for this market.

[7] A do file explanation has been made available at the annex.

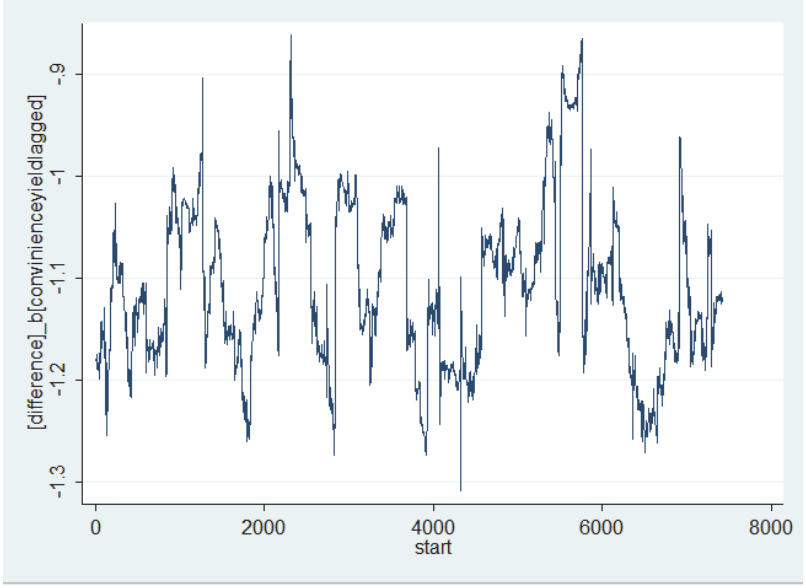


Fig.1 Estimation of k over a rolling window. (Source: compiled by authors using STATA 13)

2.2. Case 2: α, the convinience yield's long run mean is increasing over time

Looking at the successive estimations of α, one may find evidence of a visible linear trend and constant variance. Although making the assumption of α being a constant is somewhat distant to the true behavior of the parameter, if interest lies on forecasting, then it can safely be assumed so. This as long as the model is re-estimated periodically, as it has no explosive behavior, and there is no special need for an extension where α is a function of time, as in Miltersen (2003).

On the other hand, if interest lies on research, there is a more subtle implication. If the convenience yield's long term mean is increasing, and one is inclined to believe that by application of standard storage theory, e.g. Hotelling (1931) and Kaldor (1939), and that inventory levels and δ are inversely related (possibly in a non-linear way), then the model is predicting that producers are working on decreasing inventory levels (relative to production). Although not necessarily relevant for forecasting, this adds a dimension of testability of the model on theoretical grounds.

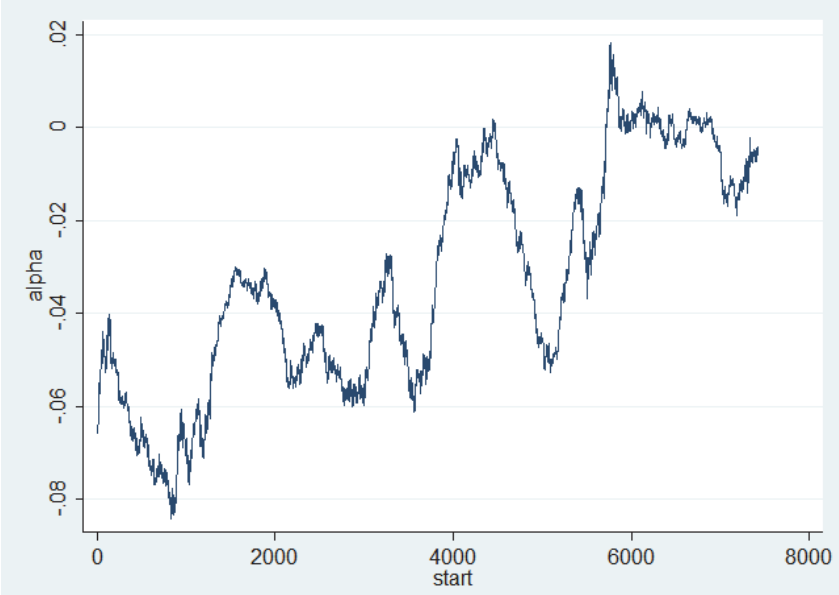
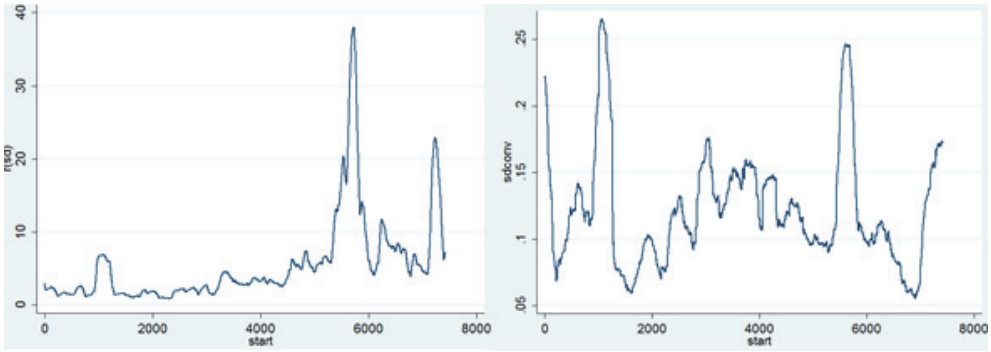


Fig.2 Estimation of α over a rolling window. (Source: compiled by authors using STATA 13)

2.3. Case 3: Both σ_1 and σ_2 estimates show an evolution that significantly differs from its modellization

Unlike the two previous examples, the variance of σ_1 and σ_2 seem to behave stochastically, and both parameters exhibit jumps. Therefore, there is solid grounds for asserting that if the forecasting ability (and self-consistency) of the model is to be improved it should be in the way of adding the possibility of stochastic volatility as in Zhu et al, (1998).



Figs.3 and 4 Estimation of σ_1 (left), and σ_2(right) over a rolling window. (Source: compiled by authors using STATA 13)

3. Conclusions

In order to perform a correct valuation of a financial derivative we need both the right model, and the right estimation strategy. The process of finding the right model is complex, and to some degree, arbitrary. Ultimately we are interested in choosing the model that will better predict the price of an instrument in the future, because this is uncertain. The analyst relies in its own expertise and a variety of heuristic tools. These include, among others, testing the reasonableness of the model's assumptions, assessing the forecasting errors of different models over a given timeframe, and assessing the stability of the estimates generated by the same model through different time windows. This work argued that this last heuristic tool, when rightly used, can be very useful as it conveys qualitative information on where is a given model falling short.

To illustrate this point, we picked a parsimonious two factor stochastic valuation model for WTI oil futures, and estimated its parameters. Then it re-estimated the same parameter over a 30 year long time series, using a fixed year-long rolling window and analyzed the stability of the estimates. The main conclusion is that the model held its ground on the k, and α parameters, and its assumptions turned unreasonable on the volatilities estimates. This allows the analyst to hint at or at least narrow the range of contesting models to be estimated for cross-validation. This is not by any means a substitute for a more forecasting error driven methodology to decide between different models, which is, most of the time, the ultimate goal of the analyst. Rather, it provides complementary information to be used at the analyst's discretion.

Future research aims to develop a less arbitrary framework for model selection, possibly factoring other cross-validation techniques and even expert knowledge into the equation.

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Annex

We transcribe the code for the .do file that allows for the replication of this work's results. Some light commentary has been labeled between asterisks for a better understanding of the code. It is important to acknowledge that this code does not include the very first step of the process, namely, the introduction of the dataset within STATA 13 framework, as it depends on its location in each user's computer.

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*Rolling Window, Sigma_1*
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*Grafico sigma_1*
twoway (line sdspot start)
*Rolling Window, Sigma_2*
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*Grafico sigma_2*
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*Test regresion multiple Serie Larga*
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mvreg Futuro_teoricooutof Futuro_outof = t
*Test regresion multiple Serie Corta*
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```


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Calculating the risk of a business model

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Abstract

The Business Model Canvas with validated information offers a visual, dynamic, real and interactive format that provides a complete idea of a new business at a single glance. In this paper, using results obtained from a group of experts in each type of scenario, we present a method that provides a value for the risk of the investment.

Keywords: *Fuzzy logic, risk, canvas, triangular fuzzy numbers, business creation.*

Introduction

The business plan (Ludevic et al., 1987) has until recently been one of the most widely used tools when creating a business.

Lately, however, the business plan has been losing momentum and usefulness in favour of the Business Model Canvas (Osterwalder and Pigneur, 2011), a business analysis and planning tool that helps entrepreneurs gain a more in-depth understanding of the risks associated with the business project. The canvas is a printable template on a sheet comprising nine modules, as shown in Figure 1.

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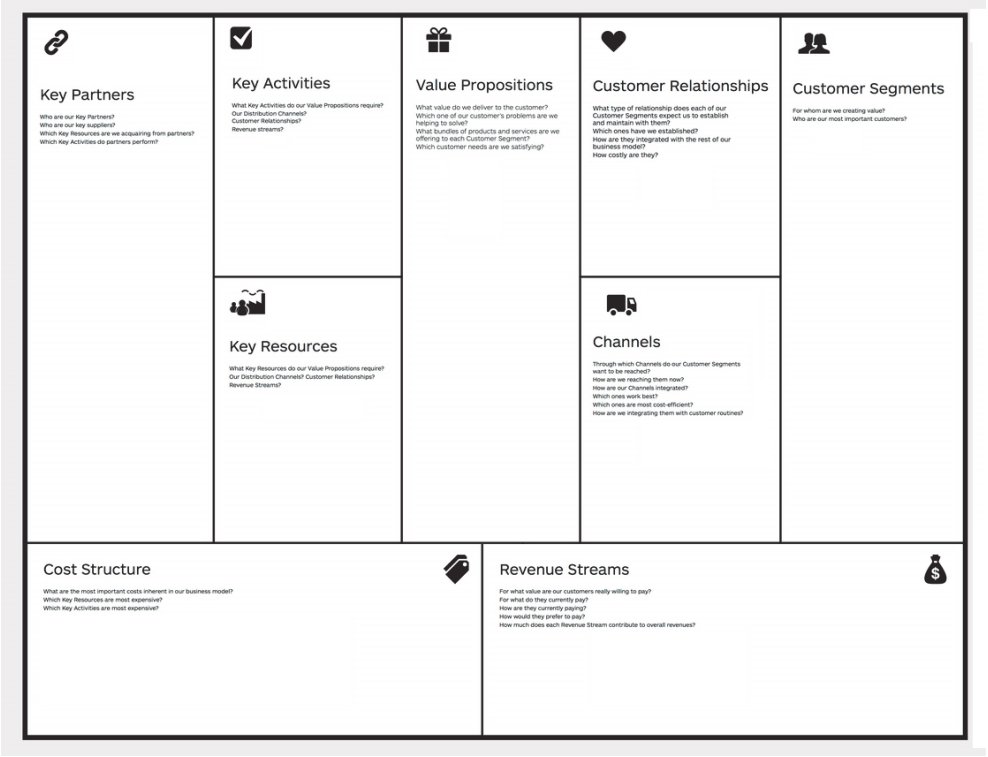

Fig.1 Business Model Canvas. Source: Authors' own data using Adobe Photochop CS6

We can summarize the main features of each module as follows.

1. Key partners

Network of suppliers and partners that contribute to the operation of a business model.

2. Key activities

The most important actions that the business must undertake to make its business model work.

3. Key resources

The most important assets for a business model to work. Each model requires different key resources. For example, a microchip manufacturer needs high-cost production facilities, while an application developer depends more on human resources.

4. Value proposition

Description of the set of products and services that create value for a specific market segment by solving a problem or satisfying a customer need. The value proposition is the factor or sum of factors that make a customer choose one business over another.

5. Customer relationships

The type of relationship desired with each market segment. The relationship can be personal or automated.

6. Channels

How a company communicates with different market segments to offer them a value proposition. The communication, distribution and sales channels establish contact between the business and the customers.

7. Customer segments

Definition of the different groups of people or entities a business targets.

8. Cost structure

All costs involved in setting up a business model.

9. Revenue streams

All revenues that are expected to be collected from each market segment.

It is mainly expected that the information entered on the canvas will help get to know customers, identify what problems or needs they have, define a solution for these, and know how much they would be willing to pay for such a solution.

The canvas tool is usually complemented by a methodology known as "Lean Startup" (Ries, 2011), which aims to obtain knowledge validated by scientific experimentation and based on different launches of a viable minimum product that shortens development cycles, measures progress and obtains valuable feedback from customers.

The canvas with validated information offers a visual, dynamic, real and interactive format that provides a complete idea of the new business at a single glance.

Given that the canvas must list all the costs involved in the start up of the business and all the revenues expected to be collected from each market segment, it seems reasonable to assume that there will be some uncertainty present.

There are several ways to include uncertainty in the magnitudes of items such as assuming that the magnitudes follow certain probability laws (Ferrer et al., 2016) or that the

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magnitudes will take certain exact values in different possible scenarios (Linares et al., 2013), which may be pessimistic (or conservative), realistic or optimistic.

With the birth of fuzzy thinking (Zadeh, 1965), a new way of working was made possible using the data from the three types of scenario (Linares et al., 2013) in the initial variables.

Zadeh's extension principle (Zadeh, 1975; Nguyen, 1978) is the basis for adding or subtracting uncertain quantities represented by fuzzy numbers. Dubois and Prade (1978) and Kaufmann, Gil Aluja and Terceño (1996) offered the usual methods for working with such operations, which constitute the fundamental arithmetic for solving multiple economic problems in which variables are highly uncertain in nature.

In this paper, using results obtained from a group of experts in each type of scenario, we present a method that provides a value for the risk of the investment, which may be of interest in motivating investment for the project.

The approach followed to develop the problem and show its possible solution is as follows:

In Section 2, we present the terms and concepts used in relation to our objective, necessary for evaluating the risk situation associated with the future business.

Section 3 details the proposed method for calculating risk.

In Section 4, a numerical example is given to clarify the whole process.

And finally, Section 5 presents the conclusions and possible lines of research to be followed in the future.

1. Preliminary considerations

Definition: Given a well-defined set U = { u1, u2, u3, u4, ... }, we shall define the fuzzy subset $\widetilde{A}$ as:

$$\widetilde{A} = \{ (u_1, \mu(u_1)), (u_2, \mu(u_2)), (u_3, \mu(u_3)), \dots \} \qquad (1)$$

where the numbers μ(ui) are numbers between 0 and 1, representing the degree to which element ui belongs to the subset according to the predicate that defines the subset.

As with ordinary sets, if we interpret these values as being the images of a characteristic function $\mu_{\widetilde{A}} : U \rightarrow [0 , 1]$, where U is an ordinary set, we can consider a fuzzy subset $\widetilde{A}$ of U as the set of ordered pairs: $\left\{ \left(x, \mu_{\widetilde{A}}(x) \right) \forall\, x \in U \right\}$

Note: We can see that if all the values μ(ui) are either 0 or 1, the classical notion of subset is restored. Consequently, the definition only extends the known theory of subsets of a set

and allows the usual set operations to be used by only extending the definition to the numbers in the open interval (0,1).

Definition 2: We shall define a fuzzy number as a fuzzy subset which the ordinary set U is the set of real numbers ($\Re$), such that the function of belonging fulfils the following conditions:

1) There is at least one value x so that $\mu_{\widetilde{A}}(x) = 1$ (normal condition).
2) $\mu_{\widetilde{A}}$ is increasing up to the minimum value x of R so that $\mu_{\widetilde{A}}(x) = 1$ and decreasing from the maximum value x of R so that $\mu_{\widetilde{A}}(x) = 1$ (convexity condition)[8].
3) $\mu_{\widetilde{A}}$ is a continuous or semi-continuous function at each point (continuous or semi-continuous condition).

Definition 3: We shall say that a fuzzy number $\widetilde{A}$ is positive when its function of belonging fulfils $\mu_{\widetilde{A}}(x) = 0$, for all $x < 0$.

Definition 4: We shall say that a fuzzy number $\widetilde{A}$ is negative when its function of belonging fulfils $\mu_{\widetilde{A}}(x) = 0$, for all $x > 0$.

Note: A very convenient way to envision a fuzzy number is by means of graphical representation of its function of belonging on coordinate axes. Usually, on the X-axis we depict the real values x and on the Y-axis the values of $\mu_{\widetilde{A}}(x)$.

In Figure 2 we see the graphic representation of a positive fuzzy number. The number is characterized by four rays, two of which are horizontal at 0, plus two more that form a triangle at a given point. Due to its shape, this type of number is called a triangular fuzzy number.

---

8 This condition is formally expressed as:

$\mu_{\widetilde{A}}(s) \geq min\left(\mu_{\widetilde{A}}(x_1), \mu_{\widetilde{A}}(x_2)\right)$, $\forall x_1, x_2 \in \Re$ i $\forall s \in [x_1, x_2]$ Note that the condition itself requires that if there are two values x_1, x_2 so that $\mu_{\widetilde{A}}(x_1) = 1$ and $\mu_{\widetilde{A}}(x_2) = 1$, any value between these also has the value *1* as an image of its characteristic function.

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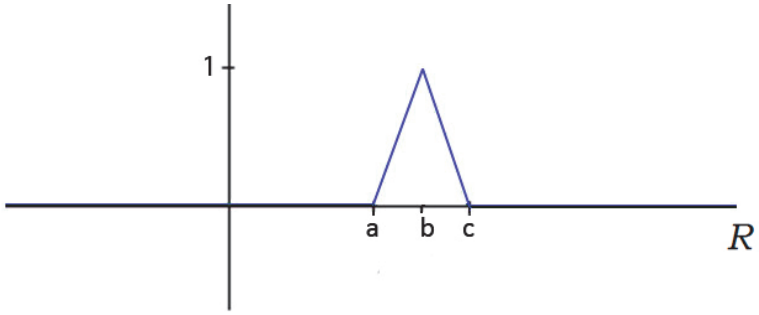


Fig.2 Example of a triangular fuzzy number. Source: Authors' own data using Adobe Photochop CS6

Proposition: Any triangular fuzzy number has a characteristic function as the function:

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 \; si \; x < a \\ \dfrac{x-a}{b-a} \; si \; a \le x \le b \\ \dfrac{c-x}{c-b} \; si \; b \le x \le c \\ 0 \; si \; x > c \end{cases}$$

Note: As the values a, b and c characterize the triangular fuzzy number, we usually write $\tilde{A} = (a,b,c)$.

Definition 5: Given two triangular fuzzy numbers $\tilde{A} = (a,b,c)$ and $\tilde{B} = (a',b',c')$.

let us define the sum of the two triangular fuzzy numbers $\tilde{A}$ and $\tilde{B}$ by means of the triangular fuzzy number $\tilde{S} =$ (a+a',b+b',c+c').

Proposition: The sum of triangular fuzzy numbers fulfils the commutative and associative properties characteristic of the sum of real numbers.

Demonstration:

(a,b,c) + (a',b',c') = (a+a',b+b',c+c') = (a'+a,b'+b,c'+c) = (a',b',c') + (a,b,c)

((a,b,c) + (a',b',c')) + (a'',b'',c'') = (a+a'+a'',b+b'+b'',c+c'+c'') = (a,b,c) + ((a',b',c') +(a'',b'',c''))

Definition 6: Given two triangular fuzzy numbers $\widetilde{A} = (a,b,c)$ and $\widetilde{B} = (a',b',c')$ so that a-a' $\leq$ b-b' $\leq$ c-c', let us define the Minkowski subtraction of the two triangular fuzzy numbers $\widetilde{A}$ and $\widetilde{B}$ by means of the triangular fuzzy number $\widetilde{R}_M = (a-a',b-b',c-c')$

Definition 7: Given two triangular fuzzy numbers $\widetilde{A} = (a,b,c)$ and $\widetilde{B} = (a',b',c')$

Let us define the subtraction of the two triangular fuzzy numbers $\widetilde{A}$ and $\widetilde{B}$ by means of the triangular fuzzy number $\widetilde{R} = (a-c',b-b',c-a')$.

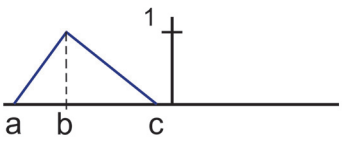
2. Method for calculating the risk of the business Canvas

Once we have determined the cost structure and revenue streams, if we calculate a triangular estimate for each of its items, the addition, subtraction and Minkowski subtraction give us the estimated profit of the CANVAS associated with the business model as a triangular number (a,b,c).

We define the risk associated with the CANVAS of a business as the proportional part of negative values in the function of belonging over the total of the triangular number (a,b,c) obtained.

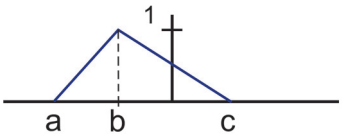
In order to make the different possible situations understandable, in Figure 3 we use visual examples of various situations to illustrate what might occur in a particular period when we determine the final result using triangular fuzzy numbers (a, b, c). In addition, each situation is accompanied by the simplified expression of their corresponding risk.

$c \leq 0$



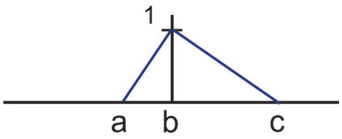
Risk of business model = 1

$b < 0$
$c > 0$



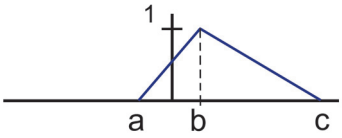
Risk = $1 - \frac{c^2}{(c-b)(c-a)}$

$b = 0$



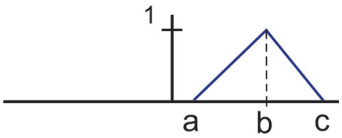
$$\text{Risk} = \frac{a}{a-c}$$

$b > 0$
$a < 0$



$$\text{Risk} = \frac{a^2}{(c-a)(b-a)}$$

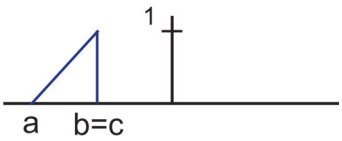
$a \geq 0$



Risk =0

$a < b = c$

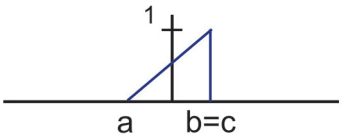
$b \leq 0$



Risk = 1

$a < b = c$

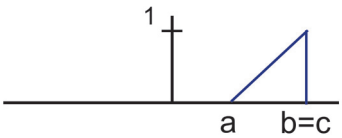
$a<0$ *i* $b> 0$



$$\text{Risk} = \left(\frac{a}{b-a}\right)^2$$

$a < b = c$

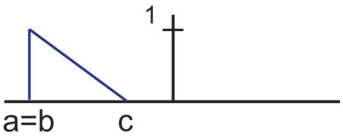
$a \geq 0$



Risk = 0

$a = b < c$

$c \leq 0$



Risk = 1

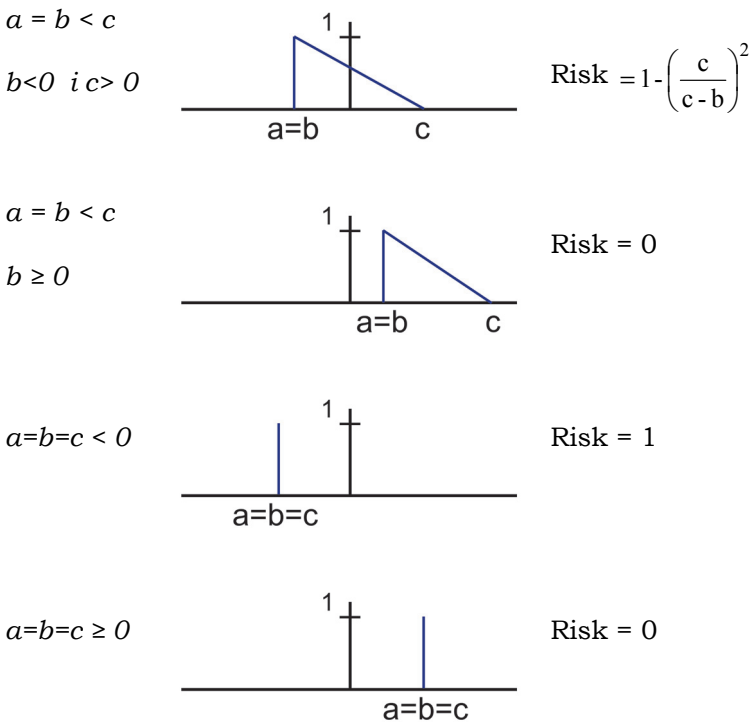


Figure 3. Possible risk situations. Source: Authors' own data using Adobe Photoshop CS6

Note that always: $0 \leq$ Risk of business ≤ 1

3. A numerical example

Let us assume a business model where the following estimates have been made for revenue streams:

Sales: (10000,12000,18000).

Contributions from partners: (24000,40000,70000).

Let us also assume that given its cost structure the following forecast is made:

Variable costs: (15000,18000,22000).

Fixed costs: (24000,28000,34000).

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In order to find the estimated total for the revenue streams section, we calculate the sum of two triangular fuzzy numbers.

(10000,12000,18000)+(24000,40000,70000) = (34000,52000,88000).

In order to find the estimated profits, the variable and fixed costs must be subtracted from this value.

However, given that variable costs are only incurred if the activity is undertaken, it is more correct to first calculate the difference using the Minkowski subtraction with variable costs and then subtract the fixed costs from the remainder using the subtraction operation.

Therefore, we do the following:

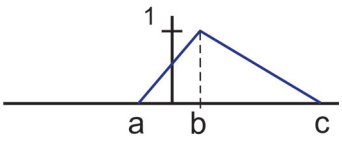
(34000,52000,88000)-M(15000,18000,22000) = (19000,34000,66000)

(19000,34000,66000)-(24000,28000,34000)=(-5000,6000,32000)

Thus, the estimated triangular fuzzy number for profits is: (-5000,6000,32000)

Given the following situation:

$b > 0$
$a < 0$



$$\text{Risk} = \frac{a^2}{(c-a)(b-a)}$$

The risk associated with our business model is:

$$\frac{(-5000)^2}{(32000-(-5000))(6000-(-5000))} \approx 0.0614$$

Given the low risk value, it seems advisable to undertake the business.

4. Conclusions

With this study we have been able to test how calculating the CANVAS allows us to obtain a value to predict the risk of the business model. This modelling of the risk has taken into account the possibility of having a direct and an indirect relationship between costs and revenues. In these types of cases, we have presented the model taking all the positive values and calculating the fuzzy number as sums of revenues – (Minkowski difference) sums of direct payments – sums of indirect payments.

We would, however, like to make several additional points regarding the study that may enrich this text.

1) There are other fuzzy numbers with which we can model the study problem and which offer certain advantages compared to triangular ones, such as the use of trapezoidal fuzzy numbers, which enable us to resolve the fact that some businesspeople may consider there not to be a single point of maximum reliability, but an interval of maximum reliability.
2) The functions and procedures offered in the model can be computed to make the results more comprehensible through visual graphics.

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Measurement of partial last square modeling in exporting companies' quality research

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Abstract

The objective of this paper is to determine the relation of the variables Quality standards, Quality control systems, and Quality Inspection Systems with the variable Quality; By identifying the variance with using the technique Partial Least Squares (PLS) is constructed. In addition, measuring the impact of quality on twenty five exporting companies with available and ability to efficiently export to USA. PLS is an efficient statistical technique that is highly suited for information systems research. In this paper, we propose both the theory underlying PLS and a discussion of the quality construct, we (a) provide an analysis of the development and features of PLS, and (b) discuss analysis of quality construct. Finally, we present guidelines for the applying of PLS as well as an explanation of the different steps implied for the assessment of the measurement model and the quality structural model.

Keywords: Measurement Quality - Partial Least Squares - Structural Equation Models – Exporting Companies – Quality Research.

Introduction

The opening of the USA market to the commercialization of Mexican avocado production was an excellent opportunity to develop a market in a culture that tended to consume natural foods, of good quality; within that a considerable amount of Mexican customary incorporating the avocado in its diet is included. Mexico's State of Michoacan. The Uruapan municipality is the largest producer of "Hass" avocados in the world. Proximity to the large USA market of 300 million inhabitants with high spending power was a unique business opportunity to take advantage of the efficient network of dealers with experience in the handling of the avocado (Bonales et al, 2011).

The universe are 18,119 companies in Michoacán established in the Registration of Business Information System of Mexico; of which only 345 firms export.

The population was obtained from the following sources: Business Information System of Mexico through the Ministry of Economy and Cexporta. We obtained 25 export companies in the perishable area in Michoacan state (Bonales et al, 2010), see table 1.

The objective of this paper is to determine the relation of the variables Quality standards, Quality control systems, and Quality Inspection Systems with the variable Quality; by identifying the variance with using the technique Partial Least Squares (PLS) is constructed.

Table 1. Survey Exporting Companies

Nº	Empresas	Nº	Empresas
1	Agrícola TREDI, SA de CV	14	Empacadora El Durazno, SA de CV
2	Aguacates Frutas de Mich, SA de CV	15	Fresch Direction Mexicana, SA de CV
3	Aguamich, SA de CV	16	Frutas Finas de Mich, S.A. de C.V.
4	AMIMEX, SA de CV	17	Grupo Purépecha, SA de CV
5	AVOFRUT, SA de CV	18	Henry, SA de CV
6	Avopack, SA de CV	19	INDEX, SA de CV
7	AVOPER, SA de CV	20	Mc Daniel, SA de CV
8	Best Farmer, SA de CV	21	Misión de México, SA de CV
9	Calavo, SA de CV	22	San Lorenzo, SA de CV
10	Chiquita, SA de CV	23	Tropic de México, SA de CV
11	Del Rey, SA de CV	24	Vifrut, SA de CV
12	Dovi, SA de CV	25	West Pack, SA de CV
13	ECO, SA de CV		

Source: Own

PLS is a variance-based structural equation modeling technique that has become very popular in management and social sciences in recent years (Nitzl, et al, 2016). Current discussions about PLS emphasis its capability to model both composites and factors (Henseler, et al, 2015) and its prediction orientation. In addition to these reasons, PLS is a useful tool for testing hypotheses especially in complex path models in an explorative manner (Chin, 2010). Researchers focus only on direct relationships and ignore mediating effects completely. This focus can heavily bias the interpretation of the results when a variable has no direct effect because its effect is mediated by another variable.

1. Methods and materials

1.1. Partial Least Squares

PLS is a method that bears some relation to principal components regression; instead of finding hyperplanes of maximum variace between the reponse and independent variables, it finds a linear regression model by projecting the predicted variables and the observable variables to a new space. Because both the X and Y data are projected to new spaces, the PLS family of methods are known as bilinear factor models.

PLS is used to find the fundamental relations between two matrices (X and Y), a latent variable approach to modeling the covariance structures in these two spaces. A PLS model will try to find the multidimensional direction in the X space that explains the maximum multidimensional variance direction in the Y space. PLS regression is particularly suited when the matrix of predictors has more variables than observations, and when there is multicollinearity among X values.

The basic PLS algorithm follows a two-stage approach. In the first stage, the latentconstructs' scores are iteratively estimated via a four-step process (Roldán et al, 2012). The second stage calculates the final estimates of coefficients (outer weights, loadings, and path coefficients) using the ordinary least squares method for each partial regression in the model. Applying both processes, the PLS algorithm aims to minimize the residual variances of dependent variables. Accordingly, PLS rests on a main assumption, that is, the predictor specification, which forms the basis for PLS modeling (Hair et al, 2011). Hence, the cause-and-effect directions between all the variables need to be specifically defined. Besides, PLS follows a segmentation process, so its estimates for a particular construct are limited to the immediate blocks, to which it is structurally tied.

1.1.1. Model Characteristics

It attempts to analyze whether the theoretical constructs are correctly gauged by the measures. In reflective measurement models, this analysis is carried out with reference to reliability and validity attributes. Formative measurement models examine, among other issues, the potential multicollinearity of indicators and assess each measure's weights. On the other hand, the structural model defines the relationships between latent variables. The structural model is basically assessed according to the meaningfulness and significance of the relationships hypothesized between the constructs. This sequence ensures that we have adequate indicators of constructs before attempting to reach conclusions concerning the relationships included in the inner or structural model (Hair et al, 2011).

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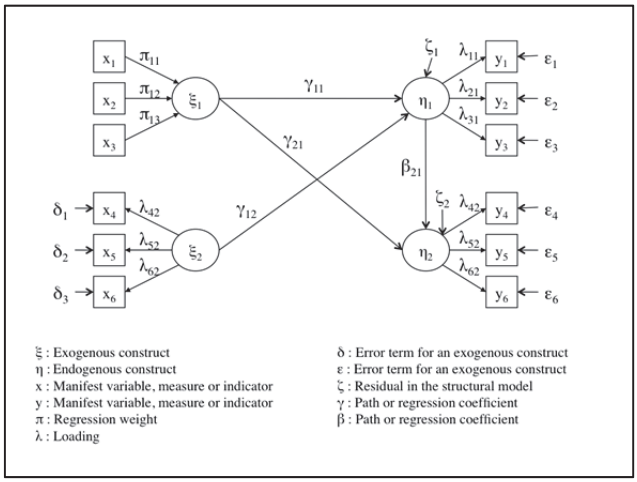

Figure 1. PLS model

The main terms used are the following Barclay et al (1995): (1) The theoretical construct or latent variable (graphically represented by a circle), which makes a distinction between the exogenous constructs (ξ) that act as predictor or causal variables of the endogenous constructs (η). (2) Indicators, measures, manifest or observable variables (graphically symbolized by squares). Figure 1 shows a graphical example of a PLS model together with a description of the principal terminology used in soft modeling.

Model structure, specifies the linear causal equations between the latent variables of the model (Guillén and Romea, 2001).

$$\eta = \beta\eta + \tau\xi + \upsilon \tag{1}$$

Model of measurement, specifies the equations that link latent variables to those observed or indicators x and y, expressed in matrix form would be:

$$x = \tau\xi + \delta$$
$$y = \beta\eta + \varepsilon \tag{2}$$

Once we have achieved a satisfactory assessment of the measurement model, we can evaluate the structural model estimates (Roldán et al, 2012). Taking into account that PLS is focused on prediction and its goal is the maximizing of the variance of the dependent variables, the first criterion in order to evaluate a PLS model is the assessment of the coefficient of determination (R^2) of the endogenous constructs (Chin, 2010). The R^2 value

represents a measure of the predictive power and indicates the amount of variance in the construct in question, which is explained by its antecedent variables in the model. The R^2 values should be high enough for the model to achieve a minimum level of explanatory power (Urbach and Ahlemann, 2010).

1.2. Quality Variable

The quality is a significant variable that it influences in the competitiveness of the companies. According to the models of competitiveness of: The European Union, the Technological Institute of Massachussets, the OECD, Michael Porter, Carlos Wagner, Alexander Serralde, Sergio Hernandez, Alexander Lerma. From the industrial point of view, the word quality means: lo better to satisfy desires and tastes with the consuming public. All the products have quality and, depending if they satisfy or not the consuming public, traditionally the systems of quality control have settled down to assure minimum norms quality related to the necessities and tastes of the consumers (Delfin and Bonales, 2015).

The norms or specifications of quality are the pattern against which the characteristics of quality of the products are moderate that make or produce and, for that reason, are the first dimension that is due to know, if it is tried to get to control the quality. The second dimension of the quality is to have the system quality control that allows to correct the differences detected in the inspection of the products that take place. The last dimension of the variable quality, is to design the inspection systems, that is to say, the forms in which the characteristics of quality of products against the norms and specifications will be compared (Delfin and Bonales, 2011), see table 2.

Coding is very important in the application of multivariate analysis because it determines when and how various types os scales can be used. Variables measured with interval and ratio scales can always be used with multivariate analysis. However, when using ordinal scales such as Likert scales, researchers have to pay spacial attention to the coding to fulfill the requirement of equidistance. For example, when using a typical five-point Likert scales with the categories (1) strongly disagree, (2) disagree, (3) neither agree nor disagree, (4) agree, and (5) strongly agree, the inference is that the “distance” between categories 1 and 2 is the same as between categories 3 and 4 (Bonales et al, 2016).

Based on the above, the following general hypothesis is presented: The application of the quality standards, the improvement of the system of control of quality and a readecuación of the system of inspection in the exporting companies from avocado to the United States of America, will bring like consequence a greater competitiveness.

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Table 2. Quality variable

Variable	Dimension	Indicator	Key
X1. Quality	X1.1 Quality standards	Objective	QQSOB
		Customers	QQSCU
		Raw Materials	QQSRM
		Competition	QQSCO
		Communication	QQSCM
	XI.2 Quality control systems	Customers	QQCCU
		Standards	QQCST
	X1.3 Quality Inspection Systems	Customers	QQICU
		Raw material	QQIRM
		Thread Tools	QQITT

Source: Own

2. Results and development of the process

The Likert scale was used for processing data; this scale is a very useful tool as it is designed to measure attitudes.

From the arithmetical point of view it is a summation scale and the score or measure of each person in the attitude in question is given by the sum of their responses to questions that was implemented (Delfin and Bonales, 2015). For this study we work with 10 items to apply at 25 exporting companies, which were reviewed in detail and were developed according to each study variable. It can get different kind of score for each variable between the maximum and minimum values as shown in the table 3.

After the estimation of the model, SmartPLS opens the results report per default. The results presentations in the Modeling window gives us a firts overview of the outcomes. As shown in figure 2 we see the standardized outer weights for the formative measurement models. We see the path coefficients as well as the R^2 values of the endogenous constructs (shown in the circles) and the discriminant validity. Then each of the measurements that are presented in the construction of this model will be explained (Bonales et al, 2016).

Table 3. Response values based on the results of the Likert scale

C	QQS OB	QQS CU	QQS RM	QQS CO	QQS CM	QQC CU	QQC ST	QQI CU	QQI RM	QQI TT
1	3	3	3	4	2	2	3	3	3	3
2	4	3	3	3	4	4	3	4	4	4
3	3	2	2	3	4	3	3	2	2	4
4	2	3	3	3	2	2	3	3	2	3
5	3	4	4	3	3	2	4	4	4	4
6	2	2	2	4	2	2	3	3	4	3
7	3	4	3	3	2	3	3	3	3	3
8	4	1	3	2	3	2	2	3	2	3
9	3	1	3	2	3	3	1	2	4	4
10	4	2	3	3	1	3	2	4	2	3
11	2	4	2	4	3	2	4	2	3	4
12	4	4	4	3	4	4	3	4	4	3
13	4	3	3	4	4	3	4	4	3	4
14	3	2	3	2	3	3	4	1	2	2
15	4	2	3	1	3	3	3	2	1	2
16	3	3	2	1	4	1	3	3	4	2
17	3	4	3	4	4	3	4	4	3	4
18	2	2	1	2	2	3	1	1	3	3
19	3	2	2	2	2	3	1	4	3	3
20	4	3	3	3	3	3	2	2	2	2
21	3	4	2	4	4	4	3	4	4	2
22	4	3	2	1	2	1	3	4	1	3
23	4	4	4	3	3	4	4	4	2	4
24	4	3	4	4	3	3	2	2	4	4
25	4	4	3	4	3	2	3	4	3	3

Source: Own

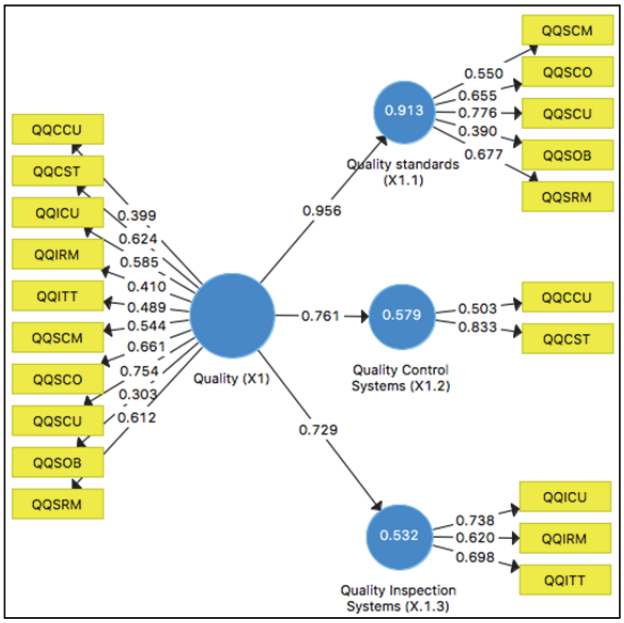

Figure 2. PLS Algorithm, based on data from field study

Table 4 shows the Coefficient of Determination (R^2). The most commonly used to evaluate the structural model. This coefficient is a measure of the model's predictive power and is calculated as the squared correlations between a specific endogenous construct's actual and predected values. The coefficient represents the exogenous latent variables' combined effects on the endogenous latent variable. The R^2 values of X1.2 (0.579) and X1.3 (0.532) can be considered moderate, whereas the R^2 value of X1.1 (0.913) is rather strong. In addition, we can see observe the same manner with the R^2_{Adj}.

Table 4. Coefficient of Determination (R^2), based on data from field study

Variables	R^2	R^2_{Adj}
XI.2 Quality control systems	0.579	0.560
X1.3 Quality Inspection Systems	0.532	0.511
X1.1 Quality standards	0.913	0.909

Table 5 shows the results report for the Path Coefficients in matrix format. The table reads from de row to the column. The value 0.956 in the X1.1 Quality standards row and the X1. Quality column is the standardized path coefficient of the relationship from Quality to Quality standars. Moreover, the three constructs explain each one (0.913, 0.579 and 0.532) of the variance of the endogenous construct, see table 4.

Table 5. Path Coefficients, based on data from field study

Variables	X1. Quality
X1.1 Quality standards	0.956
XI.2 Quality control systems	0.761
X1.3 Quality Inspection Systems	0.729

Discriminant validity is the extent to which a construct is truly distinct from other constructs by empirical standards. Thus, establishing decriminant validity implies that a construct is unique and captures phenomena not represented by other construct in the model. Table 6 illustrates this analysis with four latent variables each measured with one indicators. As can be seen, the loadings always exceed the cross-loadings. For example QQSCU loads high on its correponding construct X1.1 (0.776) but much lower on constructs X1 (0.754), X1.2 (0.593) and X1.3 (0.433). In this case, the analysis of cross-loadings suggested that descriminant validity has been established. On the contrary, the presence of cross-loadings that exceed the indicators' outer loadings would represent a descriminant validity problem.

Table 6. Discriminant Validity, based on data from field study

Item	X1. Quality	XI.2 Quality control systems	X1.3 Quality Inspection Systems	X1.1 Quality standards
QQSCU	0.399	0.503	0.166	0.368
QQCST	0.624	0.833	0.199	0.584
QQICU	0.585	0.265	0.738	0.461
QQSRM	0.410	0.031	0.620	0.332
QQITT	0.489	0.213	0.698	0.340
QQSCM	0.544	0.513	0.262	0.550
QQSCO	0.661	0.423	0.500	0.655
QQSCU	0.754	0.593	0.433	0.776
QQSOB	0.303	0.153	0.111	0.390
QQIRM	0.612	0.425	0.322	0.677

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3. Conclusions

Finally some important conclusions can be drawn on the quality variables of the exporting companies using the Partial Least Square model:

a) The object of study was twenty-five exporting companies to the USA.

b) It was described the theory of the structure of the Partial Least Square and the variables of Quality.

c) The exogenous latent variables were identified and developed: Quality standards, Quality control systems and Quality Inspection Systems.

d) It was applied to the three exogenous latent variables: the Model structure and the Model of measurement.

e) Fieldwork was carried out and the questionnaire was applied to twenty-five exporting companies.

f) The data were processed and the PLS Model was obtained, showing the results of exogenous latent variables.

g) Coefficient of Determination (R^2) was identified, in which the highest result was X1.1 Quality standards (0.913)

h) The Path Coefficients en el que el mayor resultado fue X1.1 Quality standards (0.956)

i) The Discriminant validity QQSCU loads high on its correponding construct X1.1 (0.776) but much lower on constructs X1 (0.754), X1.2 (0.593) and X1.3 (0.433).

j) The general hypothesis is tested, based on the results obtained with the Coefficient of Determination ($R^2_{Adj.}$): X1.1 Quality standards 0.909, XI.2 Quality control systems 0.56, and X1.3 Quality Inspection Systems 0.511.

k) Finally, the objective of this paper was answered to determine the relation of the variables Quality standards, Quality control systems, and Quality Inspection Systems with the variable Quality using the technique Partial Least Squares.

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Partial least square modeling measurement & technology evaluation of exporting companies

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Abstract

This work investigated the latent variables of twenty-five export companies located in Mexico, with its organization; objectives and problematic production could be known. This research paper was focused on the knowledge of tecnology latent variable. We get as a result its conceptualization, measurement and the variables that affect it (quality, price, training and distribution), as well as, the independent variables dimensions and indicators, in order to produce the research instrument. PLS is an efficient statistical technique that is highly suited for information systems research. In this regard, we present guidelines for the applying of PLS as well as an explanation of the different steps implied for the assessment of the measurement model and the quality structural model. Finally, we present information systems models of quality in which we have put previous recommendations into effect.

Keywords: Measurement Technology, Partial Least Squares, Structural Equation Models, Exporting Companies, Technology Evaluation.

Introduction

The documentary investigation focused to the knowledge of the main theories on, Competitiveness and PLS, as well as, the situation of the market of this product at worldwide level. As result of this five explanatory variables were identified that are: the quality, price, technology, training and distribution.

The opening of the USA market to the commercialization of Mexican avocado production was an excellent opportunity to develop a market in a culture that tended to consume natural foods, of good quality; within that a considerable amount of Mexican customary incorporating the avocado in its diet is included. Mexico's State of Michoacan. The Uruapan municipality is the largest producer of "Hass" avocados in the world. Proximity to the large USA market of 300 million inhabitants with high spending power was a unique

business opportunity to take advantage of the efficient network of dealers with experience in the handling of the avocado (Bonales et al, 2011).

Problematic of the industrial sector the radical process of commercial opening adopted by Mexico, generated challenges and opportunities for several Mexican companies but I question of blow competitive problems in customary companies to work in protected markets. These distortions with serious social effects are related directly to the competitiveness.

The Mexican avocado sector is underorganized with production automation and commercialization having fallen behind that of other avocado producing countries such as Chile, Israel, the USA, and Spain. There has been very little research on the competitive success factors of Mexican firms, by identifying the competitiveness factors for Mexican avocado exporting firms, this study will advance current knowledge about competitive factors for organizations in the Mexican agricultural sector that are dependent on exports to the USA (Bonales et al, 2003).

The universe are 18,119 companies in Michoacán established in the Registration of Business Information System of Mexico; of which only 345 firms export.

The population was obtained from the following sources: Business Information System of Mexico through the Ministry of Economy and Cexporta. We obtained 25 export companies in the perishable area in Michoacan state (Bonales et al, 2010), see table 1.

The objective of this paper is to determine the relation of the latent variables Quality, Prize, Training and Distribution with the variable Technology; by identifying the variance with using the technique Partial Least Squares (PLS) is constructed.

PLS is a variance-based structural equation modeling technique that has become very popular in management and social sciences in recent years (Nitzl et al, 2016). Current discussions about PLS emphasis its capability to model both composites and factors (Henseler et al, 2015) and its prediction orientation. In addition to these reasons, PLS is a useful tool for testing hypotheses especially in complex path models in an explorative manner (Chin, 2010). Researchers focus only on direct relationships and ignore mediating effects completely. This focus can heavily bias the interpretation of the results when a variable has no direct effect because its effect is mediated by another variable.

Technology that handle the competition takes to the following hypothesis: the relation that exists between the exporting companies from avocado to the United States of America, its technology depends on the quality of the fruit that takes place for export, of its price, the training of its personnel, and the distribution.

Table 1. Survey Exporting Companies

Nº	Empresas	Nº	Empresas
1	Agrícola TREDI, SA de CV	14	Empacadora El Durazno, SA de CV
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7	AVOPER, SA de CV	20	Mc Daniel, SA de CV
8	Best Farmer, SA de CV	21	Misión de México, SA de CV
9	Calavo, SA de CV	22	San Lorenzo, SA de CV
10	Chiquita, SA de CV	23	Tropic de México, SA de CV
11	Del Rey, SA de CV	24	Vifrut, SA de CV
12	Dovi, SA de CV	25	West Pack, SA de CV
13	ECO, SA de CV		

Source: Own

1. Methods and materials

1.1 Partial Least Squares

PLS is a method that bears some relation to principal components regression; instead of finding hyperplanes of maximum variace between the reponse and independent variables, it finds a linear regression model by projecting the predicted variables and the observable variables to a new space. Because both the X and Y data are projected to new spaces, the PLS family of methods are known as bilinear factor models.

PLS is used to find the fundamental relations between two matrices (X and Y), a latent variable approach to modeling the covariance structures in these two spaces. A PLS model will try to find the multidimensional direction in the X space that explains the maximum multidimensional variance direction in the Y space. PLS regression is particularly suited when the matrix of predictors has more variables than observations, and when there is multicollinearity among X values.

The basic PLS algorithm follows a two-stage approach. In the first stage, the latentconstructs' scores are iteratively estimated via a four-step process (Roldan et al, 2012). The second stage calculates the final estimates of coefficients (outer weights, loadings, and path coefficients) using the ordinary least squares method for each partial regression in the model. Applying both processes, the PLS algorithm aims to minimize the residual variances of dependent variables. Accordingly, PLS rests on a main assumption, that is, the predictor specification, which forms the basis for PLS modeling (Hair et al, 2011). Hence, the cause-and-effect directions between all the variables need to be

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specifically defined. Besides, PLS follows a segmentation process, so, its estimates for a particular construct are limited to the immediate blocks, to which it is structurally tied.

1.1.1. Model Characteristics

It attempts to analyze whether the theoretical constructs are correctly gauged by the measures. In reflective measurement models, this analysis is carried out with reference to reliability and validity attributes. Formative measurement models examine, among other issues, the potential multicollinearity of indicators and assess each measure's weights. On the other hand, the structural model defines the relationships between latent variables. The structural model is basically assessed according to the meaningfulness and significance of the relationships hypothesized between the constructs. This sequence ensures that we have adequate indicators of constructs before attempting to reach conclusions concerning the relationships included in the inner or structural model (Hair et al, 2011).

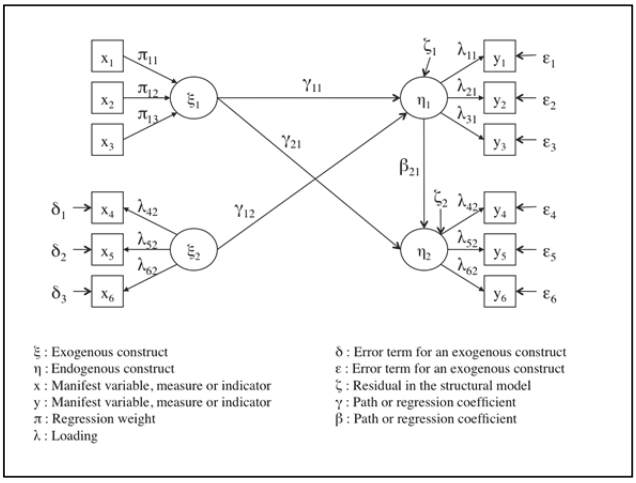

Figure 1. PLS model

1.2. Latente Variable

1.2.1. Price Variable

This variable form leaves from the models of the OECD, the Technological Institute of Massachussets, BANCOMEXT, Michael Porter, Thomas J. Peters.

The price is the only element of the marketing mixture that is generating of income; all the others are costs: therefore, it must be an active instrument of the strategy in the main areas of the decision making of marketing. The price is an important competitive tool to face and to overcome to the rivals and products near substitutes. Frequently the competition will force to reduce the prices, whereas the financial considerations intra-company produce an

opposite effect. The prices next to the costs, will determine the long term viability of the company.

The function of the analysis of the market in relation to the determination of the prices of export consists of establishing a maximum limit to the corresponding decision, from the demand of the product and the characteristics of the competitors. In the countries developing it is the situation of the market that determines the range of prices of exportation.

1.2.2. Technology Variable

Form leaves from the models of the OECD, the Technological Institute of Massachussets, Bancomext, Michael Porter, Henry Mintzberg. It is a determining variable that influences in the competitiveness of the companies. A thorough study of the variable technology was made to deduce its real definition, its dimensions and indicators.

The technology has been always point used in the speeches of the Mexican Government of an opportunistic and deceptive way. To thus they demonstrate to the National Plan of Desarrollo and the National Program of Technological Development and Científico it. The PND mentions that the competitiveness will depend crucial on the technological modernization of the country. El world of the words has crashed with the reality. The cost in science and technology is the plus under the emergent countries and comparativily inferior to Economies like the similar Spanish and Korean economic powers.

Different concepts from technology exist. The Japanese say that it is a survival exercise, because thanks to the technology the Japanese town that faces manifold natural restrictions, has been able to emphasize in the world-wide concert. They add that in the coming years, the technological administration will be key of the success of the companies everywhere of the world. The technology is defined as the knowledge organized for production aims, that are built-in in the force of work (abilities), in the equipment, or loose knowledge. The technology comprises of trinomio science-technology-production.

1.2.3. Training Variable

Qualification Including in the models of the OECD, the Technological Institute of Massachussets, BANCOMEXT, Michael Porter, Thomas J. Peters, Carlos Wagner, it is a variable that influences in the competitiveness of the companies.

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1.2.4. Distribution Variable

Table 2. Operational of Latent Vatiables

Variable	Dimension	Indicator	Key
Quality	Quality standards	Objective	QQSOB
		Customers	QQSCU
		Raw Materials	QQSRM
		Competition	QQSCO
		Communication	QQSCM
	Quality control systems	Customers	QQCCU
		Standards	QQCST
	Quality Inspection Systems	Customers	QQICU
		Raw material	QQIRM
		Thread Tools	QQITT
Price	Market	Price management	PMRMP
		Supervision	PCPSU
	Production costs	Competitors	PCPCO
		Competitive diagnosis	PCPDC
		Price integration	PCPIP
	Marketing Costs	Competitive prices	PCPPC
		Elements	PCCEL
Technology	Machinery and equipment	Use of resources	TMEUR
		Modernity	TMEMO
	Technical assistance	Consulting	TATAC
		Investment	TATIN
	Infrastructure	Competitors	TINCO
		Export	TINEX
Training	Education	Vocational training	CEDFP
		Education level	CEDNE
	Training systems	Capacitation program	CSCPC
		Training Techniques	CSCTC
		Support material	CSCMA
	Investment	Previous training	CSCFP
		Training Hours	CINHC
		Investment in sales	CINIV
Distribution	Design of the distribution channel	Client	DDCCL
		Contract	DACCO
	Distribution Channel Management	Intermediary	DACIN
		Competition	DACCM
		Normativity	DACNO
	Shipment	Distance	DEMDI
		Batch Optimization	CEMOL

Source: Own

Including in the models of the OECD, the Technological Institute of Massachussets, BANCOMEXT, Michael Porter, Miller, Alexander Serralde, the distribution channels are a variable that influences in the competitiveness of the companies. The administration of the distribution channel and its relation with the distribution channel are comparable with a marriage, as soon as it reunites to two independent organizations with shared goals. So that the relation works, each part must be clear with respect to its expectations and to openly communicate the changes perceived in the behavior of the other part, that could be opposite to the contract. Between narrower it is the relation with the distributor, is more probable

that the success of marketing is materialized. The relation must be handled with the objective to reach the long term. Reason why, their indicators are the contract that is had with the intermediaries, the knowledge of the intermediaries and the distribution channels that handle the competition takes.

1.2.5. Quality Variable

The quality is a significant variable that it influences in the competitiveness of the companies. According to the models of competitiveness of: The European Union, the Technological Institute of Massachussets, the OECD, Michael Porter, Carlos Wagner, Alexander Serralde. From the industrial point of view, the word quality means: lo better to satisfy desires and tastes with the consuming public. All the products have quality and, depending if they satisfy or not the consuming public, traditionally the systems of quality control have settled down to assure minimum norms quality related to the necessities and tastes of the consumers (Delfin and Bonales, 2015).

The norms or specifications of quality are the pattern against which the characteristics of quality of the products are moderate that make or produce and, for that reason, are the first dimension that is due to know, if it is tried to get to control the quality. The second dimension of the quality is to have the system quality control that allows to correct the differences detected in the inspection of the products that take place. The last dimension of the variable quality, is to design the inspection systems, that is to say, the forms in which the characteristics of quality of products against the norms and specifications will be compared (Delfin and Bonales, 2011), see table 2.

Coding is very important in the application of multivariate analysis because it determines when and how various types os scales can be used. Variables measured with interval and ratio scales can always be used with multivariate analysis. However, when using ordinal scales such as Likert scales, researchers have to pay spacial attention to the coding to fulfill the requirement of equidistance. For example, when using a typical five-pointLikert scales with the categories (1) strongly disagree, (2) disagree, (3) neither agree nor disagree, (4) agree, and (5) strongly agree, the inference is that the “distance” between categories 1 and 2 is the same as between categories 3 and 4 (Hair et al, 2016).

2. Results and development of the process

The Likert scale was used for processing data; this scale is a very useful tool as it is designed to measure attitudes.

From the arithmetical point of view it is a summation scale and the score or measure of each person in the attitude in question is given by the sum of their responses to questions that was implemented (Delfin and Bonales, 2015). For this study we work with 10 items to

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apply at 25 exporting companies, which were reviewed in detail and were developed according to each study variable. It can get different kind of score for each variable between the maximum and minimum values as shown in the table 3.

After the estimation of the model, SmartPLS opens the results report per default. The results presentations in the Modeling window gives us a firts overview of the outcomes. As shown in figure 2 we see the standardized outer weights for the formative measurement models. We see the path coefficients as well as the R^2 values of the endogenous constructs (shown in the circles) and the discriminant validity. Then each of the measurements that are presented in the construction of this model will be explained (Bonales et al, 2016).

Table 3 shows the Coefficient of Determination (R^2). The most commonly used to evaluate the structural model. This coefficient is a measure of the model's predictive power and is calculated as the squared correlations between a specific endogenous construct's actual and predected values. The coefficient represents the exogenous latent variables' combined effects on the endogenous latent variable. The R^2 values of Price (0.525) can be considered moderate, whereas the R^2 value of Technology (0.796) is rather strong. In addition, we can see observe the same manner with the $R^2_{\mathbf{Adj}}$.

Table 3. Coefficient of Determination (R^2), based on data from field study

Variables	R^2	R^2_{Adj}
Price	0.525	0.457
Technology	0.796	0.756

Source: Own

Table 4 shows the results report for the Path Coefficients in matrix format. The table reads from de row to the column. The value 0.728 in the Quality row and the Tecnology. Tecnology column is the standardized path coefficient of the relationship from Quality. Moreover, the four constructs explain each one (0.169, 0.069, 0.728 and 0.079) of the variance of the endogenous construct, see table 5.

Table 4. Path Coefficients, based on data from field study

Variables	Price	Technology
Distribution	-0.021	0.169
Price		0.069
Quality	0.540	0.728
Training	0.274	0.079

Source: Own

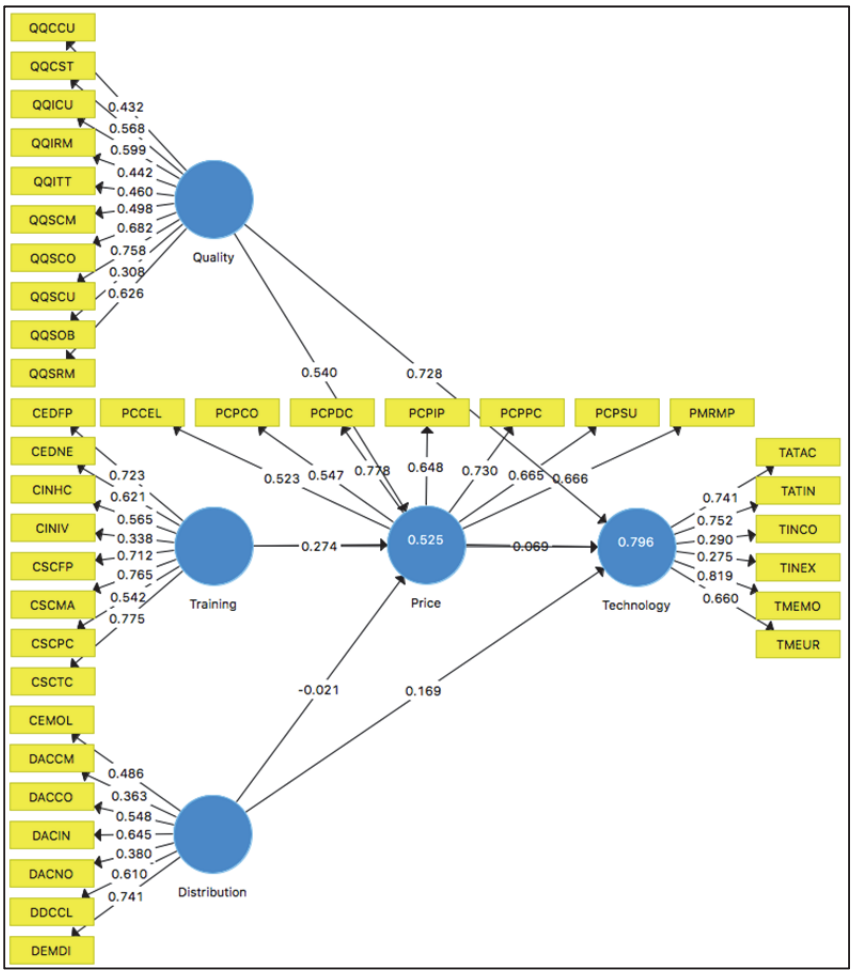

Figure 2. PLS Algorithm, based on data from field study

Table 5. Construct Reliability and Validity

Variable	Cronbach's Alpha	Composite Reliability
Distribution	0.614	0.746
Price	0.780	0.839
Quality	0.735	0.806
Technology	0.650	0.776
Training	0.789	0.845

Source: Own

Discriminant validity is the extent to which a construct is truly distinct from other constructs by empirical standards. Thus, establishing decriminant validity implies that a construct is unique and captures phenomena not represented by other construct in the model. Table 6 illustrates this analysis with four latent variables each measured with one indicators. As can be seen, the loadings always exceed the cross-loadings. For example Tecnology loads high on its correponding construct with Quality (0.869) but much lower on constructs Distribution (0.423) and Price (0.656). In this case, the analysis of cross-loadings suggested that descriminant validity has been established. On the contrary, the presence of cross-loadings that exceed the indicators' outer loadings would represent a descriminant validity problem.

Table 6. Discriminant Validity, based on data from field study

Variable	I	II	III	IV	V
I. Distribution	0.554				
II. Price	0.231	0.656			
III. Quality	0.288	0.690	0.552		
IV. Technology	0.423	0.656	0.869	0.630	
V. Training	0.354	0.575	0.573	0.595	0.645

Source: Own

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Modelling spread risk under the solvency II Framework

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Abstract

This paper attempts to analyse the suitability of different internal models for spread risk in Solvency II. For this purpose, we have used the monthly data from spread series, released by Merrill Lynch, for the period February 2000 to December 2010. Different models proposed in the literature have been estimated in order to perform backtesting. The regimen of switching normal models passes these tests so it is used to simulate the spreads in one year, which are compared with those resulting from the empirical distribution project. The results show that levels of simulated spread are more extreme than those that would result from historical stress scenarios.

Keywords: *spread risk, internal models, Solvency II, Markov Regime-Switching models*.

Introduction

Bonds with credit risk should provide superior risk-free government yields in order to compensate for possible losses of invested capital. A bond with the same coupon rate and maturity as others, but with greater credit risk, will therefore be sold at a lower price. The difference between yields, measured by the internal rate of return, which provides bond risk, and comparable bonds without risk, is the spread, or credit spread[9]. In addition, to the extent to which no-risk bonds are not exactly comparable to those that are risk free, the

[9] Thus the spread or credit spread **s(t, T)** observed in a temporary moment **t** for a specific rating category (credit spread index) and for a maturity **T** is calculated as the difference between the risk free interest rate and the interest rate provided by that rating category. At the same time, the temporary structure of spreads or the credit differential curve can be calculated as the difference between the temporary structure of the rating class and the term structure of risk free interest rates.

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spread collects these different characteristics, due to differences in liquidity, tax treatment, speculation, etc. Bond prices vary in the market according to changes in the spread. Since insurance companies invest a major part of their resources in fixed income, they are subject to spread risk. This risk is particularly relevant in the case of the Spanish general insurance companies, since according to the statistics provided by ICEA (www.icea.es) in 2014, they directly invested 67 percent of their portfolios in fixed income assets, mainly in the Eurozone.

In the new Solvency II framework companies are allowed to calculate the solvency capital requirements (SCR) using internal models approved by the regulator or using the formula set generally. The market risk module reflects the risk arising from the level or volatility of market prices of the financial instruments that influence the value of the assets and liabilities of the company. This category includes the credit spread risk, or spread, which measures the sensitivity of the value of assets, liabilities and financial instruments to changes in the level of credit spreads.

This paper specifically analyses the risks inherent to the investment in fixed income within credit ratings ranging from AAA to BBB. To do this, we evaluate the adequacy of various specifications, including GARCH models, E-GARCH and Markov regime switching models to measure the risk of spread. With this aim we have adjusted several models to the series of monthly spreads released by Merrill Lynch for the period 2000-2010 in the categories listed above. The selection of the most suitable models was made through several backtesting techniques and various statistical tests. Once the models were selected, we simulated levels for up to a year through Monte Carlo simulations, from which capital requirements could be determined.

This study contributes to the existing literature providing a new approach that has not yet been applied to the European market. Furthermore, unlike previous studies, we have included a variety of regime switching models and the selection has been done through the implementation of backtesting and not based solely on statistical criteria. The results could be very useful for the calibration of the standard model, the validation of models and, also, for insurance companies wishing to opt for an internal model.

The paper is structured as follows. In section 1 we explain the standard model. In section 2 we review the previous literature. Subsequently, section 3 outlines the models that will be analyzed. Section 3 discusses the series of indices used in the empirical analysis. Section 4 presents the models and section 5 the estimation and evaluation. Section 6 makes a comparative analysis of the results of applying the proposed models for determining capital requirements. Finally, conclusions are presented.

1.The spread risk in the standard model

The spread risk reflects the change in the value of net assets[10] due to movements of the yield curve relative to the risk free term structure. Loans, bonds, securitised assets and credit derivatives are all assessed within the spread risk module. The capital requirements for spread risk ($\mathrm{Mkt}_{\mathrm{spread}}$) are assessed for each class of instruments and then added to obtain the capital charge for spread risk:

$$\mathrm{Mkt}_{\mathrm{spread}} = \mathrm{Mkt}_{\mathrm{spread}}^{\mathrm{bonds}} + \mathrm{Mkt}_{\mathrm{spread}}^{\mathrm{securitisation}} + \mathrm{Mkt}_{\mathrm{spread}}^{\mathrm{cd}} \quad (1)$$

Where:

$\mathrm{Mkt}_{\mathrm{spread}}^{\mathrm{bonds}}$ is the capital charge for bonds and loans other than residential mortgage loans.

$\mathrm{Mkt}_{\mathrm{spread}}^{\mathrm{securitisation}}$ is the capital charge for structured credit products, such as asset backed securities and collateralised debt obligations.

$\mathrm{Mkt}_{\mathrm{spread}}^{\mathrm{cd}}$ is the capital charge for credit derivatives (such as credit default swaps or CDS, total return swaps and credit linked notes or CLNs).

In this paper we focus on corporate bond spreads. In the 4th Quantitative Impact Study (QIS4), European companies reported that over 94% of investment was made in bonds rated in the AAA- BBB range, and that there were also higher durations in higher rating classes. The spread risk capital charge on bonds is assessed through a factor-based calculation. The assumption is made that the spreads on all instruments increase, leading to an instantaneous reduction in the value of bonds (EIOPA, 2014). The capital charge for spread for bonds ($\mathrm{SCR}_{\mathrm{bonds}}$) is calculated as the sum of the product of the market value of each title (MV_{i}) by a function, $\mathrm{F}^{\mathrm{up}}(\mathrm{rating}_{\mathrm{i}}, \mathrm{duration}_{\mathrm{i}})$, which takes into account the modified duration of the bond ($\mathrm{dur}_{\mathrm{i}}$) and the rating.

$$\mathrm{SCR}_{\mathrm{bonds}} = \sum_{\mathrm{i}} \mathrm{VM}_{\mathrm{i}} \cdot \mathrm{F}^{\mathrm{up}}(\mathrm{rating}_{\mathrm{i}}, \mathrm{duration}_{\mathrm{i}}) \qquad (2)$$

The function, $\mathrm{F}^{\mathrm{up}}(\mathrm{rating}_{\mathrm{i}}, \mathrm{duration}_{\mathrm{i}})$, was calibrated to deliver a shock consistent with VaR 99.5% following a widening of credit spreads; their values are presented in Table 1[11]. This is a double entry table: credit ratings are shown in rows and modified durations in

[10] The assets allocated to policies where the beneficiaries assume the investment risks are excluded from the risk of spread, as long as these policies do not have embedded options and guarantees.

11 In order to provide a treatment according their specific risk features, there is a special treatment for covered bonds, as well as bonds issued by central governments, central banks, multilateral development banks and international organisations.

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years of bonds in columns. If the modified duration is less than one year, it should be treated as one year. For example, an AAA bond with a modified duration of five years is assumed to experience a loss of 4.5% of the market value in the stress scenario.

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Table 1. Spread risk factors for bonds

Modified duration in years (dur_i)	AAA	AA	A	BBB	BB	B	CCC or less	Without rating
(1,5]	$0.90\% \cdot dur_i$	$1.10\% \cdot dur_i$	$1.40\% \cdot dur_i$	$2.50\% \cdot dur_i$	$4.50\% \cdot dur_i$	$7.50\% \cdot dur_i$	$7.50\% \cdot dur_i$	$3.00\% \cdot dur_i$
(5,10]	$4.50\% + 0.50\% \cdot (dur_i - 5)$	$5.50\% + 0.60\% \cdot (dur_i - 5)$	$7.00\% + 0.70\% \cdot (dur_i - 5)$	$12.50\% + 1.50\% \cdot (dur_i - 5)$	$22.50\% + 2.50\% \cdot (dur_i - 5)$	$37.50\% + 4.20\% \cdot (dur_i - 5)$	$37.50\% + 4.20\% \cdot (dur_i - 5)$	$15.0\% + 1.70\% \cdot (dur_i - 5)$
(10,15]	$7.20\% + 0.50\% \cdot (dur_i - 10)$	$8.40\% + 0.50\% \cdot (dur_i - 10)$	$10.50\% + 0.50\% \cdot (dur_i - 10)$	$20.00\% + 1.00\% \cdot (dur_i - 10)$	$35.00\% + 1.80\% \cdot (dur_i - 10)$	$58.50\% + 0.50\% \cdot (dur_i - 10)$	$58.50\% + 0.50\% \cdot (dur_i - 10)$	$23.50\% + 1.20\% \cdot (dur_i - 10)$
(15,20]	$9.70\% + 0.50\% \cdot (dur_i - 15)$	$10.90\% + 0.50\% \cdot (dur_i - 15)$	$13.00\% + 0.50\% \cdot (dur_i - 15)$	$25.00\% + 1.00\% \cdot (dur_i - 15)$	$44.00\% + 0.50\% \cdot (dur_i - 15)$	$61.00\% + 0.50\% \cdot (dur_i - 15)$	$61.00\% + 0.50\% \cdot (dur_i - 15)$	$23.50\% + 1.20\% \cdot (dur_i - 10)$
>20	$12.20\% + 0.50\% \cdot (dur_i - 20)$	$13.40\% + 0.50\% \cdot (dur_i - 20)$	$15.50\% + 0.50\% \cdot (dur_i - 20)$	$30.00\% + 0.50\% \cdot (dur_i - 20)$	$46.60\% + 0.50\% \cdot (dur_i - 20)$	$63.50\% + 0.50\% \cdot (dur_i - 20)$	$63.50\% + 0.50\% \cdot (dur_i - 20)$	$\min(35\% + 0.50\% \cdot (dur_i - 20).1)$

Source: EEIOPA (2014[a])

Note: All ratings used in Table 1 are based on European Supervisory Authorities (2015) using Standard & Poor's Ratings Services ratings as an example.

2. Theoretical Review

The literature on modelling credit spreads covers three different areas. On the one hand, there are numerous theoretical studies that focus their subject matter on determining credit spreads, and that are classified into two approaches called 'structural models' and 'reduced form models'. Structural models[12] begin with Merton´s work (1974) and continue with Black and Cox (1976), and Longstaff and Schwartz (1995a), among others. They assume that the value of a company follows a stochastic process, and that the default occurs when the value of assets is less than the value of the debt issued or when it falls below a specified limit. The reduced-form models[13], as proposed in Jarrow and Turnbull (1995), Jarrow, Lando and Turnbull (1997), Duffie and Kan (1996) and Duffie and Singleton (1999), describe the credit event separately from the value of the company (exogenously). The structural models have the advantage of linking the default of a company to specific company variables (value of assets, debt value, etc.), however, they have been criticised because they obtained lower credit spreads than those observed in the market. On the other hand, spreads models resulting from the reduced-form model are better adjusted to the spreads observed in the market.

There are also studies that have analysed the determinant's factors of credit spreads. These include the work of Delianedis and Geske (2001), who studied the factors determining the spreads of US companies in the period 1991-1998. Their work explained that credit spreads are affected by taxation, liquidity, rate of return and volatility, as well as market factors. That means that the recovery rate and the probability of default only partially explain credit spreads. On one side, Brown (2001) includes factors such as the performance of treasuries, consumer confidence index, market index and liquidity in his analysis. This study incorporates information on US corporate bonds in the period 1984-1999 and concludes that 30% of the variations are explained by these factors. An important conclusion of this study is that a significant proportion of the volatility of credit spreads is due to components not related to the default. On the other side, Nerin, Cossin, Hricko and Huang (2002) studied the components of credit risk and credit derivatives of US corporate bonds in the period 1998-2000. Their work showed that the credit ratings, the level and slope of the yield curve, the share prices, volatility of the value of the company, index yields and other market factors explained approximately 60% of the changes in spreads, with the stock market being the main factor, as it explained almost 50%. Bansal, Tauchen, and Zhou (2004) incorporated a regime switching model of the term structure based in Hamilton (1989) and applied to the monthly yield on the US Treasury in the period 1964-2002. Their

[12] Also known as diffusion-based models, asset-pricing models, firm-value based models or option pricing models

[13] These models are also known as intensity models

work shows that the model can justify transition dynamics of the Treasury yields and found a link between economic cycles and regimes. Davies (2004) also analysed the determinants of credit spreads for ratings between AAA and BAA (Moody's), through a regime switching model. In this work, the free interest rate risk, the return on equity, the slope of the yield curve and industrial production are factors explaining spreads in the short term. Clarida, Sarno, Taylor and Valente (2006) evaluate the application of an asymmetric multivariate Markov model to the weekly series of euro rates for German, Japanese and American bonds for the period 1982-2000. The authors find evidence of non linearity in temporary structures and in the way that regimes are associated with economic cycles and inflation. Finally, Gabrielsen (2010) incorporates two new macroeconomic variables not considered in previous studies: inflation and an index of commodities. Their work shows that only inflation is relevant and that the determinants of spreads are relevant in times of high volatility.

There are studies that have analysed the dynamics of the spreads, that is, the behaviour of the time series. The first paper to consider variant volatility over time was written by Weiss (1984), who analysed the performance of AAA corporate bonds using an ARCH model. Similarly, Pedrosa and Roll (1998) used daily rates spreads with data provided by Bloomberg for US corporate bonds with investment grades between October 1995 and March 1997. These authors modelled the leptokurtic behaviour of the logarithmic changes in spreads through a mixture of normal distributions and found a high level of volatility persistence. Prigent, Renault and Scaillet (2001) used Moody's data and aggregated levels of credit spreads with daily observations from January 1986 to March 2000 (3,561 observations) to estimate the parameters of the models of interest rates analysed in Chan, Karolyi, Longstaff, and Sanders (1992) (CKLS models) and the model of an Ornstein-Uhlenbeck process with symmetrical jumps[14]. Subsequently, Bierens, Huang and Kong (2005) used an autoregressive model with dependent variables, conditional heteroskedasticity and jumps (ARX (1) -arch (1) -Jump model) to model the daily logarithmic variations of American spreads in the period December 1996 and August 2002. Batchelor and Manzoni (2006) investigated the impact of rating reviews on the volatility spreads of Eurobonds, finding asymmetry in the response of the volatility of spreads to changes in ratings, however, there has been very little research on the dynamic behaviour of higher order moments (volatility, skewness and kurtosis). In this regard, the work of Bond (2000) Burns (2002), Angelidis, Benos and Degiannakis (2004) and Wilhelmsson (2009) shows that GARCH models provide more adequate estimates, compared to those that only consider specifications of second moments. In particular, Bond (2000) shows how the

[14]They found that the type of model CKLS that better suits the AAA spread is that of Varsicek (1977), whereas that of Brennan and Schwartz better suits the BAA spread (1980). They also found empirical evidence for the jump model

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asymmetrical non-normal distributions (Hansen asymmetric t distribution) provide better predictions than those based on Gaussian distributions. Angelidis et al. (2004) indicate that the process average is not relevant and that the leptokurtic distributions provide better estimates of VaR (value at risk). This is due to best capture of extreme movements and thick tails. Wilhelmsson (2009) proposes a normal inverse Gaussian distribution that allows its parameters to vary over time and improves the estimate of VaR. Finally, Gabrielsen (2010) analyses the performance of various models to predict the volatility of European bond spreads. His work shows that the ARCH-SK is the model that generates the best volatility for one day, while the GJR-GARCH volatility is better for five days. Backtesting performed by the method of Christoffersen (1998) shows that there is a suitable model for temporary horizons.

3. Spreads series empirical analysis

Since our work proposes alternatives for modelling spreads it is necessary to analyse the historical series used to do this. Table 2 shows the summary statistics of the monthly series of spreads for rating categories AAA, AA, A and BBB during the time period February 2000 to December 2010, from the Corporates and Banking Index compiled by Merrill Lynch. Figure 1 shows the time evolution of the four series analysed in basic points and logarithmical changes.

Table 2. Statistics summary of the spreads series

	Spreads in levels				**Logarithmic changes**			
	AAA	**AA**	**A**	**BBB**	**AAA**	**AA**	**A**	**BBB**
Mean	37.42	79.60	163.45	395.46	0.006	0.009	0.010	0.010
Medium	29.00	49.00	85.00	216.00	0.000	0.000	0.000	0.002
Maximum	115.00	327.00	834.00	2702.00	0.383	0.397	0.385	0.415
Minimum	12.00	22.00	40.00	70.00	-0.223	-0.319	-0.299	-0.377
Standard Deviation	24.84	68.94	177.55	491.48	0.105	0.103	0.110	0.145
Asymmetric	1.16	1.80	2.30	2.61	0.731	0.867	0.894	0.126
Kurtosis	3.61	5.87	8.12	10.21	4.160	5.677	5.114	3.656
JQ-bera	32.65	120.68	270.29	386.31	19.743	57.661	43.437	2.386
Probability	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.303

Source: Own

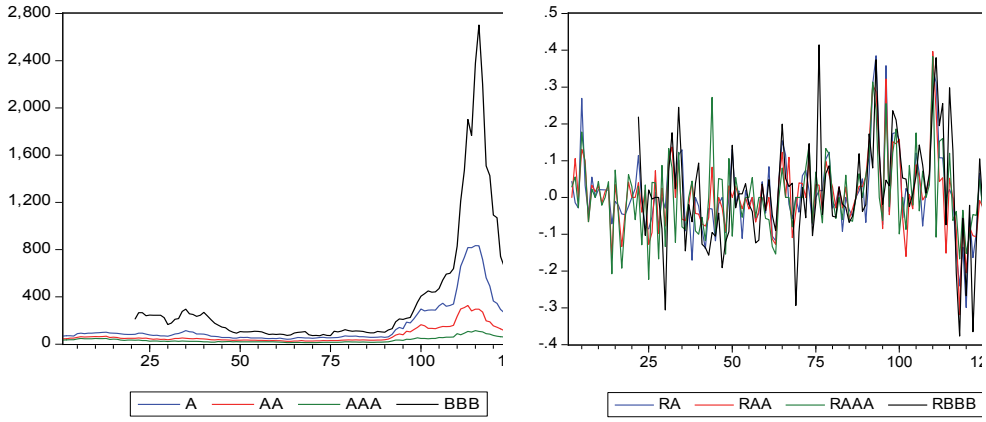

Fig.1 Temporal evolution of the MSCI Eurocredit Corporate Spreads series

In analysing the levels of credit spreads between categories of ratings we appreciate that both the mean and the standard deviation increases as the credit rating worsens. Since the credit spread of a bond compensates holders for the expected loss, a worse rating category (credit risk indicator) requires a greater spread. It is also noted that volatility in spreads increases for the worst qualified bonds, and the result is consistent with the empirical evidence shown in Duffie (1998), indicating a greater heterogeneity within those categories, that not all bonds within the same category have the same risk of spread. This characteristic is also found in the Longstaff and Schwartz (1995a)[15] series analysed. The absence of normal spreads is verified through a Jarque Bera test for all rating categories. For each sample series the null hypothesis of normality is rejected at 1%, except in the case of logarithmic returns of the BBB series. In analysing the logarithmic changes of spreads between different categories of rating, the skewness and kurtosis differ from a normal distribution and therefore the hypothesis that spreads are lognormally distributed, except for BBB, is rejected. Further, as shown in Figure 1, yields have clusters of volatility. It is therefore important to determine which model best fits the behaviour of the variance over time. The autocorrelation function (ACF) and partial autocorrelation function (PACF) of logarithmic changes in spreads shows a dependency structure in both level and in its square in the AA and A series, while the AAA and BBB series, dependence is shown only on level. This may imply that the right model to represent a rating category would be specific for each series.

[15]The authors calculate the monthly spreads for the period April 1977 to December 1992 (190 observations) for different credit ratings of three different industries (industrial, railway sector and utilities) using Moody source.

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Table 3. Dependence structure of spreads changes

	Log changes in spreads		Log changes in spreads (squared)	
AAA	**Q-Stat**	**Prob.**	**Q-Stat**	**Prob.**
1	0.263	0.608	0.180	0.671
3	7.940	0.047	0.783	0.853
6	13.627	0.034	0.884	0.990
9	17.344	0.044	2.202	0.988
12	19.676	0.073	2.691	0.997
AA	**Q-Stat**	**Prob.**	**Q-Stat**	**Prob.**
1	8.4612	0.004	3.500	0.061
3	15.789	0.001	4.658	0.199
6	19.295	0.004	6.972	0.323
9	26.189	0.002	12.657	0.179
12	28.104	0.005	17.302	0.139
A	**Q-Stat**	**Prob.**	**Q-Stat**	**Prob.**
1	15.693	0.000	7.600	0.006
3	26.022	0.000	12.787	0.005
6	30.561	0.000	14.592	0.024
9	35.769	0.000	15.076	0.089
12	37.679	0.000	18.467	0.102
BBB	**Q-Stat**	**Prob.**	**Q-Stat**	**Prob.**
1	9.461	0.002	0.014	0.905
3	14.037	0.003	4.488	0.213
6	20.470	0.002	7.857	0.249
9	24.668	0.003	13.365	0.147
12	26.304	0.010	14.325	0.280

Source: Q-statistic

From a theoretical point of view, it is assumed that credit spreads have long term mean reversion because they depend on the economic environment. During periods of economic slowdown credit spreads tend to increase, and in periods of growth they are reduced[16]. We will investigate whether the test series shows mean reversion in the analysed temporary

[16]Arak and Corcoran (1996) find empirical evidence that credit spreads are negatively correlated with economic activity and trend. Thus spreads tend to be reduced in situations where the economic activity is high or is spreading.

period[17]. With this aim, we carry out the following regression of changes in spreads at its level[18]:

$$\Delta s_{t+1} = s_{t+1} - s_t = a + bs_t + \varepsilon_{t+1} \qquad (3)$$

Where s_t is the value of the spread in the previous period and ε_{t+1} is the regression error. For there to be mean reversion, the coefficient b must be negative, and the value $-b$ indicates the rate or speed at which the credit spread reverts to its average in long-term, the latter being $-a/b$. The results of the estimate of the regression for each of the rating categories are shown in Table 4.

Table 4. Regression of changes in spreads at its level

Rating	a	T-statistic	b	T -statistic	Reversion Speed ($-b$)	Long term average ($-a/b$)
AAA	0.0062	0.6929 (0.4896)	-1.0434	12.0458 *** (0.000)	1.0434	0.0060
AA	0.0073	0.0073 (0.4019)	-0.7521	-8.9318 *** (0.000)	0.7521	0.0097
A	0.0063	0.035 (0.4829)	-0.6636	-8.1236 *** (0.000)	0.6635	0.0095
BBB	-0.0062	-0.4834 (0.6297)	0.7130	7.8780 *** (0.000)	-0.7129	0.0088

Source: Q-statistic

The results show two important facts. First, the regression coefficients are significant for the analysed series and, second, the slope coefficients of regressions are negative, except in the case of the BBB category. Furthermore, the determination coefficients take large values, meaning that the reversal effect is relevant in three of the evaluated series during the analysis period.

4. Models considered for the spread risk analysis

Table 5 shows the specifications of the models that we considered for modelling the spread risk. In particular, we considered the model of interest rates of one factor proposed by Cox, Ingersoll and Ross (1985), the normal model, and the GARCH and EGARCH models, as

[17]Credit spreads collect credit risk and liquidity premium. Changes in credit risk fluctuate with changes in real economic variables such as economic cycles and are long lasting, while changes in the liquidity premium depend on market feelings being more volatile and their duration is measured in months. Therefore it is reasonable to think that the speed of mean reversion liquidity component is greater than the credit. Thus if we look at a long term series, since bonds with better credit quality have a major component of liquidity in their spreads, it is intuitively expected to revert to its measure in the long-term before those with worse rating (Prigent *et al.*, 2001)

[18]Longstaff and Schwartz (1995b) found mean reversion in logarithmic variations in credit spreads, so they propose an Ornstein-Uhlenbeck process for modeling them

well as their Markov Switching variants. We try to assess the adequacy of the models when set out to model the risk of spreads on a long-term basis and the effect of the incorporation of regime change. As we have observed an autocorrelation of order 1 in some series of logarithmic returns in some of the previous models, an AR (1) has been incorporated to achieve a better fit.

Cox et al. (1985) or CIR model

The model of Cox et al. (1985), CIR (1985), CIR-SR or "square root process" relates the volatility of the spreads to the square root of its current level. The restriction imposed in the general formula of Chan et al. (1992) is that $\gamma = 1/2$ for which you get:

$$ds_t = \kappa(\mu - s_t)dt + \sigma\sqrt{s_t}dz_t \qquad (4)$$

Where $z_t \sim N(0;1)$. An advantage of the CIR model (1985) is that spreads cannot be negative and it associates conditional volatility with the level of spreads.

Regime switching normal model (RSN)

The regime switching models were introduced by Hamilton (1989), who described a process of autoregressive regime change. In Hamilton and Susmel (1994) various models are analysed, varying the number of regimes and the model within each regime. The normal model of regime change uses a Markov chain {i = 1,2 ....} which represents the evolution of the state of the economy, which can be in two possible situations, known as regimens. In each regime, returns follow a normal distribution, where the parameters are different for each regime:

$$r_t = \ln\left(\frac{s_t}{s_{t-1}}\right) = \mu_i + \sigma_i z_t \ (i = 1,2)$$

Where: r_t is the log return (also called the continuously compounded return), $z_t \sim N(0;1)$; $t = 1,2, \ldots n$; and i represents each one of the regimens.

Garch and Exponential GARCH (EGARCH)

The GARCH (1,1) model establishes a structure of dependency ARMA (1,1) between the squares of the observations, and is given by two equations:

$$r_t = \varepsilon_t = z_t\sigma_t$$

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2$$

Where α_0, α_1 y β_1 are positive coefficients and $\alpha_1 + \beta_1 < 1$. In case of AR(1)-GARCH(1,1) the first equation models the mean of the process (r_t) as an autoregressive first order process:

$$r_t = \phi_0 + \phi_1 r_{t-1} + \varepsilon_t$$

The EGARCH model is one of the most used asymmetric conditional heteroskedasticity models. In this model the conditional variance is a function of asymmetric function of lagged disturbances. For example, the AR(1)-EGARCH (1,1) model is often given by the following expressions:

$$r_t = \phi_0 + \phi_1 r_{t-1} + \sigma_t z_t$$

$$\ln \sigma_t^2 = \alpha_0 + \alpha_1 \left(\theta \frac{|z_{t-1}^2|}{\sigma_{t-1}} - E\left(\frac{|z_{t-1}^2|}{\sigma_{t-1}} \right) \right) + \beta_1 \ln \sigma_{t-1}^2$$

Regime Switching GARCH model (RSGARCH)

This model was proposed by Gray (1996) and later modified by Klaassen (2002). Marcucci (2005) compares a set of GARCH, EGARCH and GJR-GARCH models considering regime switching and different distributions for errors in order to assess their ability to predict the volatility of S&P 100 stock market index. The model we propose in our analysis is an RS-GARCH (1,1) with two regimes and meets the following specification:

$$r_t = \mu_{i,t} + \varepsilon_t \text{ where } \varepsilon_t = \sigma_{i,t} z_t$$

Unlike the RSN model which assumes a constant volatility, models volatility regime changes vary according to an ARMA process, so the equation for the variance for each system is given by:

$$\sigma_{i,t}^2 = \omega_i + \alpha_i (\varepsilon_{t-1})^2 + \beta_i \sigma_{t-1}^2 \quad (i = 1,2)$$

Gray (1996) proposes a measure of the volatility σ_t^2 that is not dependent:

$$\sigma_t^2 = p_{1,t}(\mu_1^2 + \sigma_{1,t}^2) + (1 - p_{1,t})(\mu_2^2 + \sigma_{2,t}^2) - (p_{1,t}\mu_1 + (1 - p_{1,t})\mu_2)^2$$

Under this proposal, the conditional variance depends only on the regime and not on the entire history of the process.

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Table 5. Specification of the used models in the analysis

Model	Specification
Lognormal	$r_t = \mu + \sigma z_t$
CIR (1985)	$ds_t = (\alpha + \beta s_t)dt + \sigma\sqrt{s_t}dz_t$
AR(1)-GARCH (1,1)	$r_t = \phi_0 + \phi_1 r_{t-1} + \varepsilon_t;\ \ \varepsilon_t = \sigma_t z_t;\ \ \sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$
AR(1)-EGARCH (1,1)	$r_t = \phi_0 + \phi_1 r_{t-1} + \varepsilon_t;\ \ \varepsilon_t = \sigma_t z_t;$ $\log(\sigma_t^2) = \omega + \alpha_1 \left\lvert \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right\rvert + \gamma_1 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \beta_1 \log(\sigma_{t-1}^2)$
RSN (k regimes)	$r_t = \mu_i + \sigma_i z_t;\ (p_t = 1, \dots, k)$
RS-GARCH (1,1)	$r_t = \mu_i + \varepsilon_t;\ \ \varepsilon_t = \sigma_{i,t} z_t;\ \ \sigma_{i,t}^2 = \omega_i + \alpha_i(\varepsilon_{t-1})^2 + \beta_i \sigma_{t-1}^2; (i = 1,2)$

5. Estimations and models selection

In this section we present the results of estimating models from the analysed series and conduct a comparison using backtesting methods and different statistical criteria. All models were estimated using TSM and E-Views 6 software. Table 6 shows the parameters resulting from the estimate using the methods of least squares (CIR model) and maximum likelihood (other models). The model of two regimes (RSN2) provides a more stable regime with negative expected returns and one that is more volatile with positive expected returns. The high significance of the parameters of the equation for the variance of the GARCH models is consistent with the volatility of the empirical data. As shown, the estimation of regime switching models involves a large number of parameters and therefore a more complex estimation. In fact, the RS-GARCH model could not be estimated in one case (BBB series), either because the algorithm presented convergence problems, or it was not possible to find a robust solution with consistent parameters.

After the models estimation we tested whether residues exceeded the normality test. In the event that the residues are not normal, the adjustment of the model may not be suitable since it would indicate that there are outliers not properly captured. Residues for regime switching models can be calculated assigning the residue to each sub-model, according to its conditional probability of occurrence or using only residues associated with the higher probability model. The programme used (TSM) uses weighted residuals. The fulfilment of normality was performed using the Jarque-Bera test. Table 7 shows how only models that take into account the existence of regimes exceed the normality test with a 99% confidence for the entire series, however, the E-GARCH models pass the test for BBB and AA series, while the Garch overcomes it for AAA and BBB. Finally, the BBB series also exceeds the normality test for the lognormal model, but not so the CIR model, which is clearly inadequate for capturing the tail risk.

Table 6. Estimated parameters of models

		AAA	AA	A	BBB
Lognormal	μ	0.006199	0.009419	0.009776	0,01002
	σ	0.0104688	0,102985	0.110246	0.144957
CIR	α	-0.00245456	-0.00442262	0.0000756	-0.00246304
	β	-0.00977	-0.01155	1.85469	-0.12450
	σ	0.00704	0.01163	0.0150	0.03589
AR(1)-GARCH (1,1)	ϕ_0	0.00395	0.002067	0.004646	0.005138
	ϕ_1	-0.075996	0.183758	0.34293	0.289175
	ω	0.0000686	0.000169	0.000606	0.002244
	α_1	-0.054157	0.076975	0.129191	0.057877
	β_1	1.057418	0.917453	0.819805	0.830236
AR(1)-EGARCH(1,1)	ϕ_0	0.003078	-0.00229	0.004444	-0.002564
	ϕ_1	-0.115545	0.363302	0.327246	0.191797
	ω	-7.679935	-5.402819	-0.495288	-8.078133
	γ_1	0.041428	1.209742	0.247904	0.143538
	α_1	0.225285	0.068904	0.072145	0.302077
	β_1	-0.679141	0.049082	0.93381	-0.922305
RSN2	**P(1|1) P(1|2)**	0.96232/0.03768	0.081369/0.18631	0.78197/0.21803	0.91525/0.08475
	P(2|1) P(2|2)	0.84536/0.15464	0.051064/0.94894	0.08447/0.91552	0.14814/0.85186
		Regime 1:	**Regime 1:**	**Regime 1:**	**Regime 1:**
	μ_1/σ_1.	-0.00641/0.08671	0.06769/0.16996	0.00574/0.16966	0.03401/0.17022
		Regime 2:	**Regime 2:**	**Regime 2:**	**Regime 2:**
	μ_2/σ_2	0.28853/0.0535	-0.00623/0.06665	-0.00902/0.06494	-0.02857/0.07294
RS-GARCH (1,1)	**P(1|2) P(2|1)**	0.00002/0.99998	0.98752/0.01248	0.39609/0.60391	-/-
	P(1|2) P(2|1)	0.00001/0.99999	0.00845/0.99154	0.00001/0.99999	-/-
		Regime 1:	**Regime 1:**	**Regime 1:**	**Regime 1:**
	μ_1	-0.02748	-0.00359	-1.03661	-
	ω_1	0.88123	0.08789	837.263	-
	α_1	-0.03200	-0.17249	-0.24486	-
	β_1	0.62220	0.95720	0.66902	-
		Regime 2:	**Regime 2:**	**Regime 2:**	**Regime 2:**
	μ_2	0.00520	-0.00326	0.00508	-
	ω_2	0.01073	0.00362	0.06769	-
	α_2	0.03200	0.08338	0.19176	-
	β_2	-0.62220	0.45108	0.56468	-

Table 7. Residuals normality test (Jarque Bera and p-values)

	AAA	AA	A	BBB
Lognormal	19.74 (0.000)	57.66 (0.000)	43.43 (0.000)	2.38 (0.303)
CIR	194.68 (0.000)	420.53 (0.000)	276.87 (0.000)	157.13 (0.000)
AR(1)-GARCH (1,1)	3.98 (0.136)	26.75 (0.000)	26.69 (0.000)	4.33 (0.115)
AR(1)-EGARCH(1,1)	9.71 (0.008)	6.52 (0.038)	22.22 (0.000)	1.66 (0.435)
RSN2	0.99 (0.608)	3.01 (0.221)	2.92 (0.232)	2.06 (0.356)
RS-GARCH (1,1)	20.11 (0.000)	0.5231 (0.770)	53.35 (0.000)	-

In addition to normality, the correct specification of the models requires analysis of whether residues and their squares are correlated. A frequently used test is proposed by the Ljung and Box Q. Table 8 shows the p-values associated with the residuals and their squares. Again, except for the lognormal model and the RSN2 excluding an AR (1) process, residues and its squares do not present autocorrelation.

The models we've reviewed in the previous sections are designed to analyse the risk of spread which the insurer incurs by calculating the value at risk (VaR). Formally, VaR is the loss such that the probability that it is equal to or greater than is equal to p:

$$\mathrm{VaR}_p(Y) = \mathrm{Prob}(Y \geq Y^*) = p$$

In the parametric models, quantiles are direct functions of the standard deviation and therefore GARCH models and those of regime change have a dynamic measure of VaR defined as:

$$\mathrm{VaR}_{t+1}^p(r) = \mu + \sigma_{t+1} F_p^{-1}(z)$$

Estimates models measure the risk of spread of the insurer through the technique of value at risk (VaR). A form of validation involves the application of backtesting and thus assesses the number of times that the losses exceeded the VaR during the analysed period. Tests which have been used are Kupiec (1995) and Christoffersen (1998). Unlike the usual situation for applying models to high frequency series to assess the long-term risk, there is not enough data to estimate models and then to apply the backtesting for a later period. Therefore, models of the same series on which they have been estimated are analysed, without performing a new modification in the estimation of the parameters thereof. If a model exceeds the test, we understand that it has an adequate number of failures in a sufficiently long period to be assumed that it is appropriate to measure the risk. In the specific case of the analysed series, Christoffersen reported no values for the test of independence because there no consecutive violations, which means that all models pass the specific test.

Table 8. Residuals (RES) and squared residuals (RES2). Q.statistic (p-values)

Q(j)	Lognormal		CIR		AR(1)-GARCH		AR(1) EGARCH		RSN2	
	RES	RES2	RES	RES2	RES	RES2	RES	RES2	RES	RES2
AAA										
1	0.608	0.738	0.533	0.545	-	-	-	-	0.117	0.878
3	0.047	0.883	0.014	0.234	0.024	0.75	0.012	0.805	0.061	0.424
6	0.034	0.992	0.018	0.358	0.016	0.955	0.017	0.986	0.048	0.168
9	0.044	0.986	0.011	0.402	0.025	0.811	0.021	0.972	0.066	0.093
12	0.073	0.996	0.018	0.402	0.050	0.932	0.034	0.993	0.140	0.049
AA										
1	0.004	0.095	0.000	0.013	-	-	-	-	0.208	0.994
3	0.001	0.283	0.000	0.080	0.119	0.175	0.156	0.497	0.083	0.864
6	0.004	0.382	0.002	0.130	0.227	0.319	0.161	0.741	0.156	0.942
9	0.002	0.14	0.000	0.002	0.345	0.382	0.268	0.688	0.167	0.709
12	0.005	0.087	0.000	0.000	0.506	0.574	0.390	0.083	0.258	0.867
A										
1	0.000	0.009	0.000	0.000	-	-	-	-	0.011	0.802
3	0.000	0.006	0.000	0.000	0.476	0.668	0.384	0.803	0.009	0.384
6	0.000	0.027	0.000	0.000	0.816	0.590	0.744	0.675	0.0024	0.266
9	0.000	0.089	0.000	0.000	0.712	0.790	0.653	0.852	0.0280	0.491
12	0.000	0.079	0.000	0.000	0.875	0.756	0.832	0.732	0.083	0.396
BBB										
1	0.002	0.812	0.000	0.000	-	-	-	-	0.004	0.411
3	0.003	0.188	0.000	0.000	0.353	0.401	0.210	0.818	0.006	0.148
6	0.002	0.175	0.001	0.001	0.037	0.624	0.135	0.880	0.001	0.099
9	0.003	0.099	0.000	0.000	0.031	0.298	0.117	0.622	0.002	0.119
12	0.010	0.214	0.001	0.001	0.051	0.448	0.214	0.537	0.003	0.222

The Kupiec test analysis reveals that only RSN2 models exceed the test for all categories of spread. The other models do not do so, as they present a higher number of failures than allowed, except in the BBB series, where all pass the test. This suggests that best fit models depend on the data used, and the selection thereof must be performed specifically. RSN is the only model that exceeds the backtesting, so is a good candidate for building internal models to measure the risk of spread, as it shows a good balance between simplicity and adjustment. In the analysed series, however, the inclusion of an autoregressive model could help achieve a better fit and eliminate the autocorrelation problems detected.

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Table 9. Test Kupiec (POF) at 99.5% (p-values)

	Lognormal	AR(1)-GARCH(1,1)	AR(1)-EGARCH(1,1)	RSN2
AAA				
FAILURES	3	3	3	0
POF (99.5%)	0.0372	0.0372	0.0372	0.2042
AA				
FAILURES	5	5	4	0
POF (99.5%)	0.0006	0.0006	0.0053	0.2042
A				
FAILURES	4	4	4	0
POF (99.5%)	0.0056	0.0056	0.0056	0.2042
BBB				
FAILURES	2	2	1	0
POF (99.5%)	0.1422	0.1422	0.6113	0.2226

6. Evaluation of models behaviour

In this section we will analyse the projected spreads results for each rating by adjusted RSN2 models, compared with the result of applying annual empirical distribution. For this purpose 50,000 Latin hypercube sampling (LHS)[19] type simulations were used for the logarithmic returns of each of the twelve months simulated. Later we accumulate that income and, from the last historical value of each category of spread, we simulate the spreads levels projecting it to one year. These values will be compared with those that would result from applying the historical annual scenarios.

Table 10 shows key statistics (mean and various percentiles) of the empirical distribution of annual arithmetic yields spreads, calculated as accumulation of the monthly returns of each series (AAA, AA, A and BBB). This data provides us with information about the historical changes that spreads have experienced, using a moving window of twelve months. For example, the average annual change of the AAA spreads along the analysed sample amounted to an increase of 15.43%. Secondly, the spreads statistics values projected to one year are shown by applying the previous empirical variations to the recent historical spread levels. This data provides us with information about what the levels spreads to one year would be if the empirical yields observed in the past were applied. For example, since the worst scenario for the annual empirical AAA rating there has been an annual increase of 231.25%, and if we were to apply this stress scenario to the last data sample the result would be a spread of 2.62% over the free rate risk. Thirdly, previously estimated spreads statistics simulated by Markov switching models regime are shown. Finally, the last four columns show information about the percentage differences between the levels simulated by models and those projected for the annual empirical distribution. It is seen how, in general, the simulated models generate spreads levels for one year with maximum values

[19]The LHS simulation method is a method of sampling by stratification. It allows a distribution to be recreated with greater accuracy for the same number of iterations than the common Monte Carlo method, in which the samples are selected completely randomly

which exceed those resulting from being applied to the worst historical scenario of rising, and the minimum values that result being lower than those that would imply the best historical drawdown scenarios. In the projection of the central percentile we observe less variability than that resulting from the most extreme percentiles.

To follow, we will establish how to calculate the risk of spread of an insurance company in Solvency II using internal models for the case of a bond. The risk of the spread of a bond reflects the change in the value of assets due to movement of the interest rate curve in relation to the risk free curve. To calculate the capital weight resulting from an internal model, enough simulations for all spreads categories through appropriate models should be carried out. The impact on the price of a bond can be analysed through the generated spreads. Thus, the effect of the spread risk after 12 months is estimated through changes in the price of the bond for which the following equation is used:

$$P_{12} = \sum_{t=1}^{n} \frac{CF_t}{(1 + r + CS_{12})}$$

Where:

P_{12} is the price of the bond in the month twelve.

CF_t is the cash flow of the bond.

r is the internal rate of return risk free that is supposed to be constant throughout the analysed period.

CS_{12} is the simulated spread for a given rating category in the month twelve This spread is an average of the spreads of different simulated ratings, since it must take into account the effect of the transition matrices between one year ratings. This matrix shows the likelihood that a bond with a particular rating changes to another rating in the time period considered. Thus, to simulate the level of spread of a rating at month 12 we may have to simulate all rating categories. There is a high probability that the bond does not change its credit rating, but there is also a likelihood of rating migration (increases or decreases)

Since Solvency II requires that companies that use an internal model must establish their capital charge based on VaR (99.5%) a year, the maximum expected loss is calculated at the confidence level established as the quantile 0.5 % of the distribution of gains and losses of the analysed bond.

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Table 10. Statatistics summary of the projected values through the annual empirical distribution and the RSLN models

Stats.	Annual empirical variations(%)				Projected values applying empirical variations (1) (5)				Simulated spread values applying RSN (2) (%)				Differences in spreads variations (1-2)/(2) (%)			
Average (%)	AAA	AA	A	BBB	AAA	AA	A	BBB	AAA	AA	A	BBB	AAA	AA	A	BBB
	15.43	24.12	31.32	43.06	0.91	2.01	3.38	9.74	0.95	2.20	3.52	7.91	4.65	9.41	4.29	-18.80
0.0	-50.43	-65.14	-72.42	-78.82	0.39	0.56	0.71	1.44	0.19	0.43	0.63	0.91	-51.10	-23.27	-11.06	-36.88
0.1	-50.26	-65.06	-72.14	-78.64	0.39	0.57	0.72	1.45	0.31	0.65	0.92	1.81	-21.50	14.31	28.12	24.77
0.5	-49.56	-64.76	-71.03	-77.95	0.40	0.57	0.74	1.50	0.36	0.77	1.16	2.28	-9.84	35.25	55.35	52.05
1.0	-48.12	-64.12	-70.13	-77.06	0.41	0.58	0.77	1.56	0.39	0.85	1.26	2.54	-5.71	45.74	64.68	62.41
2.5	-41.52	-61.07	-66.38	-68.66	0.46	0.63	0.86	2.13	0.44	0.96	1.45	2.92	-5.07	52.16	67.53	36.79
5.0	-38.46	-53.21	-60.06	-61.39	0.49	0.76	1.03	2.63	0.49	1.06	1.62	3.30	0.02	39.43	57.56	25.63
10.0	-34.89	-31.07	-41.40	-55.73	0.51	1.12	1.51	3.01	0.55	1.18	1.83	3.80	6.52	5.48	21.34	26.19
15.0	-33.33	-24.75%	-28.64	-48.13	0.53	1.22	1.83	3.53	0.60	1.27	1.99	4.19	12.98	4.07	8.63	18.68
25.0	-26.86	-19.54%	-17.53	-28.02	0.58	1.30	2.12	4.90	0.67	1.42	2.26	4.83	16.76	9.10	6.68	-1.53
75.0	38.23	30.77	35.29	70.36	1.09	2.12	3.48	11.60	1.12	2.48	4.08	9.42	2.97	17.21	17.32	-18.77
85.0	66.95	72.58	106.96	156.01	1.32	2.80	5.32	17.43	1.31	3.11	5.03	11.71	-0.50	11.23	-5.42	-32.86
90.0	92.72	114.21	158.60	215.48	1.52	3.47	6.65	21.48	1.46	3.67	5.86	13.53	-4.13	5.79	-11.77	-37.02
95.0	145.26	198.95	213.03	300.25	1.94	4.84	8.04	27.26	1.72	4.69	7.36	17.07	-11.24	-3.06	-8.57	-37.36

Stats.	**Annual empirical variations(%)**				**Projected values applying empirical variations (1) (5)**				**Simulated spread values applying RSN (2) (%)**				**Differences in spreads variations (1-2)/(2) (%)**			
	AAA	AA	A	BBB	AAA	AA	A	BBB	AAA	AA	A	BBB	AAA	AA	A	BBB
Average (%)	15.43	24.12	31.32	43.06	0.91	2.01	3.38	9.74	0.95	2.20	3.52	7.91	4.65	9.41	4.29	-18.80
97.5	179.56	272.15	329.90	323.08	2.21	6.03	11.05	28.81	2.01	5.82	9.02	20.89	-8.90	-3.54	-18.36	-27.48
99.0	198.33	328.98	383.20	431.57	2.36	6.95	12.42	36.20	2.42	7.62	11.73	26.37	2.66	9.72	-5.54	-27.17
99.5	211.72	349.98	389.17	455.13	2.46	7.29	12.57	37.80	2.79	8.99	14.00	31.06	13.16	23.26	11.35	-17.85
99.9	227.34	375.88	392.22	470.94	2.59	7.71	12.65	38.88	3.86	13.22	19.48	44.86	49.15	71.45	53.98	15.39
100.0	231.25	382.35	392.98	474.89	2.62	7.81	12.67	39.15	6.81	26.87	32.26	89.19	160.14	243.92	154.62	127.81

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7. Conclusions

The Solvency II project carried out a review of the valuation rules of the financial situation in order to improve the control and measurement of the risks to which European insurers are exposed. Under this new framework, the determination of capital requirements can be calculated using a standard model or internal models previously approved by the regulator. This paper provides guidance on how to develop an internal model for measuring the risk of spread from a theoretical point of view and by analysing the empirical behaviour of different alternatives proposed in the literature. The Kupiec and Christoffersen test analyses reveals that only the Markov change regime models, where the returns generated in each scheme are normally distributed (RSLN), overcome these tests for all categories of spread. Levels in spreads are later simulated by Latino Hibercubic simulation, comparing the spread levels with those that would result from applying the empirical annual distribution. We can see how simulated models generate spreads levels to one year, the maximum values of which exceed those resulting from spreads that had been applied to the worst historical scenario of rise. They also simulate minimum values that are lower than those that imply the best historical scenarios of decrease. In the central percentiles projection, lower discrepancy resulting from the most extreme percentiles is observed. This could indicate that the RSLN models, which are the best suited to historical data, overcoming backtesting, could not properly project future levels as they lack mean reversion and over adjust extreme performance data. This is a major challenge not only for insurance companies wishing to develop their internal models, but also for the supervisory authorities responsible for approving their use.

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Lógica difusa y medidas de distancias no monotónicas aplicadas a la psicología del color orientada a los millennials

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Resumen

El propósito de este trabajo de investigación es mostrar a través de la utilización de lógica difusa la importancia de implementar la psicología del color para vincularlo los gustos, preferencias, valores de conforman el perfil de los millennials con la intención de tener un acercamiento comunicativo por medio de la utilización del color rojo. Los datos fueron recabados a través de la revisión de la literatura, en primera instancia, después se dio una valoración matemática y se midieron las distancias para encontrar el grado de comunicación que tiene el color rojo con los millennials, ya que éste se vincula con pasión, consumo, practicidad y selectividad, elementos que revelan la actitud de este segmento de mercado.

Se utilizaron distintas técnicas de verificar distancias como la distancia de Hamming y el promedio ponderado ordenado (OWA). También se utilizó el operador de distancia promedio ponderada ordenada (OWAD); y finalmente se hicieron cálculos con operadores no monotónicos de NOMOWA, que tiene valor negativos y que exhiben la no monotonicidad. Una posible aplicación de estos operadores no monotónicos OWA es en el dominio de agregación multicriterio guiada por cuantificadores en la donde el cuantificador guía no es monotónico (Yager, 1999).

Keywords: *Lógica difusa, distancias no monotónicas, psicología del color, millennials.*

Introducción

Los millennials son un grupo generacional ampliamente investigado en los últimos tiempos, su importancia es dada por varios elementos distintivos, uno de ellos es la cantidad poblacional que representa a nivel mundial, otro es su comportamiento distintivo al haber crecido dentro de un entorno altamente tecnológico, con dispositivos móviles de todo tipo que les facilitan la vida y que incluso llegan a sobrevaluar sus propias competencias con el uso de ellos. Se han vuelto un nicho de mercado atractivo para el marketing sensorial y

digital ya que son jóvenes acostumbrados a dar su opinión y a ser escuchados, a guiarse no por lo establecido formalmente sino por comportamientos intuitivos y dándole crédito a la información útil a partir de la interacción entre ellos por medio de redes sociales.

En consecuencia, las investigaciones relacionadas con la generación de vínculos comunicativos y la utilización, en este caso del color rojo para incidir en su toma de decisiones cada día cobra mayor importancias. Las compañías en todo el mundo usan señales como colores y formas para transmitir una imagen de marca determinada y para aumentar la probabilidad de compra del consumidor (Hess & Melnyk, 2016).

Por otra parte el impacto del color de las marca parece estar relacionado no sólo con los significados relacionados con el producto y / o el consumo, sino también con la información sensorial. En otras palabras, los comentarios espontáneos no sólo se referían al impacto de otros elementos de diseño, sino también a marcas auténticas, que están conectadas al color y al sabor (Kauppinen Räisänen & Luomala, 2010).

Como explica (Heller, 2012), las personas que trabajan con los colores, de forma individualizada (arquitectos, diseño gráficos, modistas, etc.), deben saber el efecto o sensación que los colores producen, ya que su resultado debe ser único y universal. En este sentido este trabajo de investigación está basado en la medición de percepciones acerca del color rojo y lo que este comunica vinculado con las características que definen a los millennials. Cuando se hace referencia a una "sensación" o "percepción" de tipo subjetivo que no es posible o no se puede medir, se recurre a otro concepto: el de valuación, utilizando en la teoría de los números borrosos. (Kaufmann & Gil Aluja, 1986).

Por medio de la revisión de la literatura se realiza en primer instancia la matematización de los colores y después la matematización de las palabras que definen a los millennials por medio de lógica difusa, la cual proporciona un marco matemático que permite modelar la incertidumbre de los procesos cognitivos humanos de forma que pueda ser tratable por un computador (González, 2011), después se mide la:

1) Distancia de Hamming ponderada (WHD) para mostrar las coincidencias más definitorias entre las características de los millennials y los colores que comunican los valores que los distinguen, de tal forma que los investigadores de este grupo generacional tenga más información que les permita acercarse a ellos.
2) Posteriormente se utilizó la Distancia (de Hamming) media ponderada ordenada OWAD.
3) Después la Distancia de Hamming ponderada no monotónica- NON MONOTONIC-WHD.
4) Finalmente se calcula la distancia media ponderada ordenada no monotónica. NON MONOTONIC OWAD.

Todas las herramientas anteriores permitirán observar que con el uso de las ponderaciones ajustadas a las caracteristicas de forma individualizada significa que el grado de incertidumbre es menor por lo tanto la distancia es también menor (WHD y NON-NOMOTONIC WHD). En cambio cuando las ponderaciones estan solo ordenadas el grado de incertidubre es más grande por eso la distancia también aumentan (OWAD y NON MONOTONIC OWAD).

1. Literature review

1.1 Psicología del color

Goethe fue el precursor de la psicología del color. En su tratado se opuso a la visión puramente física y matemática de Newton, proponiendo que el color depende también, en realidad, de nuestra percepción, en la que se halla involucrado el cerebro, y de los mecanismos del sentido de la vista.

Artistas, filósofos, psicólogos y científicos han estudiado los efectos del color durante siglos, desarrollando multitud de teorías sobre el uso del color. El número y variedad de tales teorías demuestra que no pueden aplicarse reglas universales: la percepción del color depende de la experiencia individual. Para Goethe era de la mayor importancia comprender las reacciones humanas al color, y su investigación marca el inicio de la psicología moderna del color (Illusion Studio, 2016).

El estudio hecho por Kauppinen, Räisänen & Luomala, 2010 sugiere que una función muy importante desempeñada por los colores es la de la comunicación. La evidencia muestra el papel de los colores como un medio de comunicación,. También identificamos diferentes significados. La comunicación del color está relacionada con el contexto, y existe una relación entre los significados del color de empaque y el tipo de producto. De igual forma las investigación de marketing sugieren que los consumidores hacen elecciones de productos basadas en los significados que asocian con los colores y cómo los colores del producto encajan con sus preferencias de color en general (Madden, Hewett & Roth, 2000).

1.2. Colores y su aplicación en marketing

Hay una inmensa variedad de investigaciones relacionadas con la utilización de colores en marketing, ya sea para motivar la compra, generar ambientes, percepciones, comportamientos, etc. Los colores, la música o los aromas entran en escena para generar diferenciación y crear estados de ánimo positivos en los clientes. Con ello se mejora de manera apreciable el rendimiento de la tienda (García, Gómez, Molinillo & Yagüe, 2015).

En la investigación de Wauters, Brengman & Mahama, 2014), en relación al efecto que evocan los colores, sus hallazgos confirman que el color de fondo realmente tiene un impacto sobre la eficacia de anuncios. En general, los colores son una herramienta clave en

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la publicidad, los empaques y los diseños de tiendas ya que provocan atención e influyen en la percepción y comportamiento. (Aslam, 2006), además de que cada color tiene significados psicológicos que afectan en la percepción cognición y comportamiento (A.J. Elliot, Maier, Moller, Friedman & 2007).

En relación a los colores de las etiquetas de vino, algunas investigaciones indican que las etiquetas coloridas del vino pueden ser percibidas como frívolas y poco serias (Taegue, 2004). Las etiquetas en general muestran distintas señales al consumidor, las tradicionales que representan castillos y viñedos en colores ricos y neutrales dan una connotación de alta calidad (De Mello & Pires, 2009).

Por otra parte, la teoría de la experiencia temprana sostiene que la aversión al negro está ligada a los temores primordiales por la oscuridad, la noche y lo desconocido, mientras que el gusto por el blanco está ligado a la luz, el fuego y el sol (Mead & Baldwin, 1971). En cuestiones religiosas, la literatura y en los medios masivos el blanco simboliza bienestar mientras que el negro simboliza malestar, por consecuencia los niños hacen asociaciones positivas con el color blanco y negativas con el negro (Frank & Gilovich, 1988).

1.3. Millennials

Los millennials usan el consumo para definir quiénes son y para distinguirse de sus padres. las marcas parecen ser muy importantes para identidad y confort. El hecho de que han vivido en un mundo que cambia rápidamente, los vendedores tienen una oportunidad sustancial para identificar nuevos productos y experiencias que ellos disfrutarán. En la investigación hecha por (Charters et al, 2011) es evidente que el uso de la imagen, el color y el posicionamiento difieren marcadamente de un país a otro entre los consumidores millennials.

Este segmento ha sido calificado como narcisista, en el sentido de llegar a sobreestimar sus propias habilidades, el narcicismo es conceptualizado como buscador de atención, lo cual explica porque son asiduos a engancharse en actividades que les permitan ganar atención, sin embargo se ha demostrado que el narcisismo se correlacionan con niveles más altos de autoeficacia y compromiso laboral (Crappell, 2012). La investigación hecha por Credo, Lanier, Matheme & Cox (2016) demuestra que las actividades sociales y orientadas hacia el servicio son cada vez más importantes para los jóvenes.

En el estudio hecho por Elliot & Barth (2012) en relación al diseño de etiquetas de vino para los millennials, se observó que como consumidores millennials desean una mezcla más equilibrada de mente y corazón (Harris Interactive, 2001), lo que puede explicar su intento de satisfacer las necesidades emocionales a través del consumo, usan el empaque de vino como una señal para evaluar los productos alternativos y seleccionar aquellos que coinciden

con sus propios valores (Lockshin, 2003), eligiendo a menudo las marcas de la misma manera que eligen a sus amigos (Veontis & Papasolomou, 2007).

Los millennials se caracterizan, entre otras cosas por individualistas, no quieren ser parte de una masa de consumidores, son selectivos y les gusta el trato personalizado, esto incluye los productos con el diseño, color y características adecuadas para cada comprador. En este sentido, los colores suelen jugar un papel clave porque están asociados con la cultura de consumo o subculturas de consumo. La noción de una asociación entre colores y culturas se remonta (Chebat & Morrin, 2007), por lo menos, a (Luckiesh, 1927) que propuso que la raza, las costumbres y el tipo de civilización afectan las preferencias de color. Ante esto, es necesario observar la intensión de compra, que se refiere a la posibilidad de que los consumidores compren un producto dado que un componente crítico de todo el proceso de compra es la satisfacción que experimentan los consumidores al realizar la compra, la cual se basa en su confirmación o des confirmación de sus expectativas al hacer la compra (Chen, Yen, Kuo & Capristrano, 2016).

1.4. Implementación de Fuzzy Logic

El análisis de los datos con la implementación del modelo Fuzzy permite tener una superior veracidad en la recolección de datos y maximiza la autenticidad en la interpretación de resultados. Este modelo reduce la incertidumbre de la información ya que se adapta a la realizada del consumidor y potencializa la eficiencia en la toma de decisiones (Casabayó & Borja, 2010).

La toma de decisiones en el ámbito empresarial resulta cada vez más compleja, como consecuencia de los avances tecnológicos, la diversidad de mercados, la multiplicidad de productos que han motivado la necesidad de que la intuición del empresario debe ser completada por esquemas científicos cada vez más complejos . La complejidad de los problemas y la imprecisión de las situaciones han hecho necesario introducir esquemas matemáticos más flexibles y adecuados a la realidad. En este sentido, la teoría de conjuntos borrosos ha permitido el nacimiento de unas técnicas que van a facilitar la solución de aquellos problemas en los que la incertidumbre aparece de manera fundamental (Kaufmann & Gil Aluja, 1986).

La teoría de los conjuntos difusos se utiliza para desarrollar un procedimiento de evaluación más ajustado a la realidad. El enfoque que se propone permite tratar las dimensiones del impacto como variables lingüísticas y, basándose en ellas, formular criterios valorativos en forma de reglas difusas (García, Félix Benjamín & Bello Pérez, 2014).

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1.5. Distancia de Hamming

La distancia de Hamming (Hamming, 1950) es una técnica útil para calcular las diferencias entre dos elementos, dos conjuntos, etc. En la teoría de conjuntos difusos, puede ser útil. Por ejemplo, para el cálculo de distancias entre conjuntos difusos, intervalos de valor Fuzzy, conjuntos difusos intuicionistas y conjuntos difusos intuicionistas de intervalo. La distancia de Hamming adaptada de Gil (2012), para se puede formular de la siguiente forma:

Hamming entre dos subconjuntos borrosos $\underset{\sim}{D}$ y $\underset{\sim}{P}_j$:

$$\underset{\sim}{D} = \begin{array}{|c|c|c|c|c|} \hline C_1 & C_2 & C_3 & \cdots & C_n \\ \hline \mu_1 & \mu_2 & \mu_3 & \cdots & \mu_n \\ \hline \end{array}$$

$$\underset{\sim}{P}_j = \begin{array}{|c|c|c|c|c|} \hline C_1 & C_2 & C_3 & \cdots & C_n \\ \hline \mu_1^{(j)} & \mu_2^{(j)} & \mu_3^{(j)} & \cdots & \mu_n^{(j)} \\ \hline \end{array}$$

es la siguiente:

$$d(\underset{\sim}{D}, \underset{\sim}{P}_j) = \sum_{i=1}^{n} |\mu_1 - \mu_1^{(j)}| = |\mu_1 - \mu_1^{(j)}| + |\mu_2 - \mu_2^{(j)}| + \ldots + |\mu_n - \mu_n^{(j)}|$$

Para llevar a cabo la comparación se acostumbra emplear la llamada “distancia relativa de Hamming”. Se obtiene dividiendo la distancia absoluta por el número de características, cualidades o singularidades, en esta caso “n”. Será entonces:

$$\delta(\underset{\sim}{D}, \underset{\sim}{P}_j) = \frac{1}{n} \cdot d(\underset{\sim}{D}, \underset{\sim}{P}_j) = 1/n \sum_{i=1}^{n} |\mu_1 - \mu_1^{(j)}| = \frac{1}{n} \left(|\mu_1 - \mu_1^{(j)}| + |\mu_2 - \mu_2^{(j)}| + \ldots + |\mu_n - \mu_n^{(j)}| \right)$$

1.6. Operadores OWA

Los operadores OWA son instrumentos que permiten agregar información. Es decir, a partir de una serie de datos se puede obtener un valor único representativo de la información. Como característica adicional de los operadores OWA se puede decir que el valor representativo obtenido es un valor agregado de acuerdo con unos parámetros de optimismo/pesimismo predeterminados (Merigó, 2008).

El operador de distancia promedio ponderada ordenada (OWAD) es utilizado como herramienta de análisis de datos ya que proporciona una familia parametrizada de

operadores de agregación de distancia entre la distancia máxima y la distancia mínima, además puede ampliarse aún más utilizando otros tipos de distancias tales como la distancia euclidiana, la distancia de Minkowski y la distancia cuasi-aritmética (Merigo & Gil-Lafuente, 2012).

$$\left(\frac{1}{n} \sum_{i=1}^{n} | a_i - b_i | \right)$$

1.7. No monotónico OWA/OWAD

Puede definirse como sigue para dos conjuntos X = {x1, x2, …, xn} and Y = {y1, y2, …, yn}.

Definición 1. Un operador OWAD no monotónico de dimensión n es un mapeo NOM-OWAD: [0, 1]n × [0, 1]n → [0, 1] que tiene un vector de ponderación asociado W, con $\sum_{j=1}^{n} w_j = 1$ and wj ∈ [-1, 1] tal que:

$$\text{NOM-OWAD } (\langle x1, y1\rangle, \langle x2, y2\rangle, \ldots, \langle xn, yn\rangle) = \sum_{j=1}^{n} w_j D_j,$$

Donde Dj es la j valor de mayor distancia individual de | xi - yi |.

Cabe señalar que la principal diferencia con el NOM-OWAD es que el vector de ponderación wj: puede ser inferior a 0. En la definición 1 el estudio considera entre -1 y 1. Pero también es posible considerar casos más generales, OWA pesado (Yager, 1999), (Merigo & Gil-Lafuente, 2012), donde los pesos pueden moverse entre -∞ y ∞.

2. Aplicaciones

Se trata de una investigación cualitativa transaccional, con datos primarios y secundarios obtenidos del análisis de libros, artículos científicos y revistas especializados en marketing. Se realizó una selección de literatura que de manera extensa y detallada describen la importancia del color, rojo sus aspectos generales, sus simbolismos y lo que comunican, así como las características y conceptos que se les asocian. Las principales obras consultadas fueron las de la (Tabla 1).

Como segunda etapa y a partir de la revisión de literatura especializada en marketing en relación al la generación milenio. Se revisaron algunos artículos científicos y, una vez descartados aquellos que no abordaban directamente la caracterización de los millennials en relación a sus hábitos de consumo, se enuncia en la (Tabla 2) los artículos consultados para definir el perfil característicos de los millennials.

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Tabla 1. Literatura asociada al color y su significado

TÍTULO	AUTOR/AÑO
A cor como informação: a construção biofísica, lingüística e cultural da simbologia das cores	(Guimarães, 2000)
Cromoterapia - cores para a vida e para a saude	(Duarte, 2002)
Psicodinâmica das Cores em Comunicação	(Farina, 2002)
Da cor à cor inexistente	(Pedrosa, 2005)
O universo da cor	(Pedrosa, 2006)
Psicodinâmica das Cores em Comunicação	(Heller, 2012)

Fuente: Elaboración Propia

Tabla 2. Literatura asociada a los millennials

TÍTULO	AUTOR/ AÑO
Engagement and talent management of Gen Y	(Weyland, 2011)
Generation Y values and lifestyle segments	(Valentine & Powers, 2013)
Millennial (Gen Y) Consumer Behavior, Their Shopping Preferences and Perceptual Maps Associated With Brand Loyalty	(Ordun, 2015)
Consumer Expectation from Online Retailers in Developing E-commerce Market: An Investigation of Generation Y in Bangladesh	(Rahman, 2015a)
Optimizing Digital Marketing for Generation Y: An Investigation of Developing Online Market in Bangladesh	(Rahman, 2015b)
Hip to be cool: A Gen Y view of counterfeit luxury products	(Francis & Burgess, 2015)
Discovering the Millennials' Personal Values Orientation: A Comparison to Two Managerial Populations	(Weber, 2015)
Effects of consumer embarrassment on shopping basket size and value: A study of the millennial consumer	(Satinover N., Raska, & Flint, 2015)
Adaptive use of social networking applications in contemporary organizations: Examining the motivations of Gen Y cohorts	(Shirish, Boughzala, & Srivastava, 2016)
Online Purchase Behavior of Generation Y in Malaysia	(Muda, Mohd, & Hassan, 2016)
Acceptance of Online Mass Customization by Generation Y	(Junker, Walcher, & Blazek, 2016)
Gen y: a study on social media use and outcomes	(Omar, 2016)
Creativity and Cognitive Skills among *Millennials*: Thinking Too Much and Creating Too Little	(Corgnet, Espín, & Hernán-González, 2016)
Gen Y customer loyalty in online shopping: An Integrated model of trust, user experience and branding	(Bilgihan, 2016)
Generation X vs. Generation Y A decade of online shopping	(Lissitsa & Kol, 2016)

Fuente: Elaboración Propia

Posteriormente se elaboró una matriz del perfil de los millennials, se tomaron las palabras que describen la personalidad de los millennials, (Tabla 3), donde matemáticamente se describen las palabras que los definen, generando un perfil, en la cual son considerados los datos contenidos en la bibliografía consultada. Estableciendo una escala endecadária donde el intervalo numérico de 0 al 1, de acuerdo a las mayores apariciones de cada palabra en los artículos consultados, así como la intensidad de la descripción de cada constructo. Posteriormente se desarrolla un cuadro para establecer una relación entre los palabras asociadas al perfil de los millennials y el grado de asociación de cada una de estas palabras con el color rojo.

Posteriormente se elaboró una matriz de los colores (Tabla 3) , la cual es un descriptor matemático de los colores, donde son considerados los datos contenidos en la bibliografía consultada. Fue estructurada por medio de una escala endecadária donde el intervalo numérico de 0 al 1, en que 0 (menor intensidad de la característica presente en el color considerado por los autores) y 1 (total intensidad de la característica presente en el color rojo considerado por los autores). se desarrolla un cuadro para establecer una relación entre los colores y sus significados.

Tabla 3. Valoración conjunta del color, el perfil del millennial, y las distancias

Características	**Esperanza**	**Tecnología**	**Libertad**	**Innovacción**	**Equilibrio**	**Amistad**
Perfil Milennials	1	1	1	0.9	0.9	0.9
Color	**0**	**0**	**0**	**0**	**0**	**0**
Calculo 1	**1**	**1**	**1**	**0.9**	**0.9**	**0.9**
Características	**Comunicación**	**Percepción (interacción)**	**Educación**	**Cooperativismo**	**Dinamismo - multitarea**	**Intelecto Fuerte /inteligencia**
Perfil Milennials	1	0.8	0.8	0.8	1	0.7
Color	**0.1**	**0**	**0**	**0**	**0.2**	**0**
Calculo 1	**0.9**	**0.8**	**0.8**	**0.8**	**0.8**	**0.7**
Características	**Conectividad**	**Liderazgo**	**Sensibilidad emocional**	**Atención**	**Ética**	**Egocentrismo**
Perfil Milennials	1	0.7	0.7	0.2	0.7	1
Color	**0.3**	**0**	**0**	**0.9**	**0**	**0.3**
Calculo 1	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
Características	**Confianza**	**Valores Humanos**	**Entretenerse**	**Crecimiento**	**Cambios**	**Alegria**
Perfil Milennials	0.6	0.7	0.8	0.6	0.8	0.8
Color	**0**	**0.1**	**0.2**	**0**	**0.2**	**0.3**
Calculo 1	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.5**

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Características	**Impersonalidad**	**Placer**	**Belleza**	**Salud**	**Depresión**	**Protección**
Perfil Milennials	0.5	1	0.7	0.4	0.4	0.6
Color	**0**	**0.5**	**0.3**	**0**	**0**	**0.2**
Calculo 1	**0.5**	**0.5**	**0.4**	**0.4**	**0.4**	**0.4**
Caracteristicas	**Energía Positiva**	**Facilidad**	**Solvencia**	**Experienciar**	**Estabilidad**	**Lujo /sofisticación**
Perfil Milennials	0.9	0.8	0.4	1	0.3	0.2
Color	**0.5**	**0.4**	**0**	**0.7**	**0**	**0.4**
Calculo 1	**0.4**	**0.4**	**0.4**	**0.3**	**0.3**	**0.2**
Características	**Fidelidad**	**Autoconfianza**	**Actividad / Ansiedad**	**Amor**	**Coherencia**	**Pasión**
Perfil Milennials	0.2	0.9	0.8	0.8	0.2	0.9
Color	**0**	**0.7**	**0.6**	**1**	**0**	**1**
Calculo 1	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**
Características	**Poder**	**Trabajo/Actividad Física**	**Selectividad**	**Madurez**	**Competitividad**	**Consumo**
Perfil Milennials	0.5	0.6	0.2	0.4	0.8	1
Color	**0.4**	**0.5**	**0.3**	**0.5**	**0.9**	**0.9**
Calculo 1	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Características	**Compromiso**	**Nutrición /Alimentación**	**Practicidad**	**Aburrido**	**Características**	**Compromiso**
Perfil Milennials	0.1	0.3	0.8	0.3		
Color	0	0.2	0.8	0.3		
Calculo 1	0.1	0.1	0	0		

Fuente: Elaboración Propia

Con el objetivo de obtener datos más exactos se realizan cálculos que nos permitan conocer de manera óptima la distancia que hay entre la valoración matemática de la caracterización de los millennials y la representación matemática del color rojo para cada una de las palabras que los definen. En la Tabla 4 se muestran los datos utilizando Distancia de Hamming, Distancia de Hamming ponderada (WHD) y Distancia (de Hamming) media ponderada ordenada (OWAD).

Tabla 4. Utilización de Distancia de Hamming, WHD y OWAD para calcular distancias

Cálculos		Distancia de Hamming	WHD			OWAD		
Caracteristicas		HD	W	W*	Resultados W	$\hat{W}$	$\hat{W}$*	Resultados $\hat{W}$
W1	**Esperanza**	1	0.35	0.026	0.026	0.85	0.064	0.064
W2	**Tecnología**	1	0.65	0.049	0.049	0.65	0.049	0.049
W3	**Libertad**	1	0.30	0.022	0.022	0.65	0.049	0.044
W4	Innovacción	0.9	0.21	0.016	0.014	0.55	0.042	0.037
W5	Equilibrio	0.9	0.21	0.016	0.014	0.35	0.026	0.024
W6	Amistad	0.9	0.21	0.016	0.014	0.35	0.026	0.024
W7	**Comunicación**	0.9	0.55	0.041	0.037	0.30	0.023	0.018
W8	Percepcion (interaccion)	0.8	0.21	0.016	0.013	0.25	0.019	0.015
W9	Educación	0.8	0.21	0.016	0.013	0.25	0.019	0.015
W10	Cooperativismo	0.8	0.21	0.016	0.013	0.21	0.016	0.013
W11	**Dinamismo - multitarea**	0.8	0.25	0.019	0.015	0.21	0.016	0.011
W12	Intelecto Fuerte /inteligencia	0.7	0.21	0.016	0.011	0.21	0.016	0.011
W13	**Conectividad**	0.7	0.35	0.026	0.018	0.21	0.016	0.011
W14	Liderazgo	0.7	0.21	0.016	0.011	0.21	0.016	0.011
W15	Sensibilidad emocional	0.7	0.21	0.016	0.011	0.21	0.016	0.011
W16	Atención	0.7	0.21	0.016	0.011	0.21	0.016	0.011
W17	Ética	0.7	0.21	0.016	0.011	0.21	0.016	0.011
W18	**Egocentrismo**	0.7	0.35	0.026	0.018	0.21	0.016	0.010
W19	Confianza	0.6	0.21	0.016	0.009	0.21	0.016	0.010
W20	Valores Humanos	0.6	0.21	0.016	0.009	0.21	0.016	0.010
W21	Entretenerse	0.6	0.21	0.016	0.009	0.21	0.016	0.010
W22	Crecimiento	0.6	0.21	0.016	0.009	0.21	0.016	0.010
W23	Cambios	0.6	0.21	0.016	0.009	0.21	0.016	0.008
W24	Alegria	0.5	0.21	0.016	0.008	0.21	0.016	0.008
W25	Impersonalidad	0.5	0.21	0.016	0.008	0.21	0.016	0.008
W26	**Placer**	0.5	0.25	0.019	0.009	0.21	0.016	0.006
W27	Belleza	0.4	0.21	0.016	0.006	0.21	0.016	0.006
W28	Salud	0.4	0.21	0.016	0.006	0.21	0.016	0.006
W29	Depresión	0.4	0.21	0.016	0.006	0.21	0.016	0.006
W30	Protección	0.4	0.21	0.016	0.006	0.21	0.016	0.006
W31	Energía Positiva	0.4	0.21	0.016	0.006	0.21	0.016	0.006
W32	Facilidad	0.4	0.21	0.016	0.006	0.21	0.016	0.006
W33	Solvencia	0.4	0.21	0.016	0.006	0.21	0.016	0.005

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Cálculos		Distancia de Hamming	WHD			OWAD		
Caracteristicas		HD	W	W*	Resultados W	$\hat{W}$	$\hat{W}$*	Resultados $\hat{W}$
W34	**Experienciar**	0.3	0.65	0.049	0.015	0.21	0.016	0.005
W35	Estabilidad	0.3	0.21	0.016	0.005	0.21	0.016	0.003
W36	Lujo /sofisticación	0.2	0.21	0.016	0.003	0.21	0.016	0.003
W37	Fidelidad	0.2	0.21	0.016	0.003	0.21	0.016	0.003
W38	Autoconfianza	0.2	0.21	0.016	0.003	0.21	0.016	0.003
W39	Actividad / Ansiedad	0.2	0.21	0.016	0.003	0.21	0.016	0.003
W40	Amor	0.2	0.21	0.016	0.003	0.21	0.016	0.003
W41	Coherencia	0.2	0.21	0.016	0.003	0.21	0.016	0.002
W42	Pasión	0.1	0.21	0.016	0.002	0.21	0.016	0.002
W43	Poder	0.1	0.21	0.016	0.002	0.21	0.016	0.002
W44	Trabajo/actividad Física	0.1	0.21	0.016	0.002	0.21	0.016	0.002
W45	Selectividad	0.1	0.21	0.016	0.002	0.21	0.016	0.002
W46	Madurez	0.1	0.21	0.016	0.002	0.21	0.016	0.002
W47	Competitividad	0.1	0.21	0.016	0.002	0.21	0.016	0.002
W48	**Consumo**	0.1	0.85	0.064	0.006	0.21	0.016	0.002
W49	Compromiso	0.1	0.21	0.016	0.002	0.21	0.016	0.002
W50	Nutrición /alimentación	0.1	0.21	0.016	0.002	0.21	0.016	0.000
W51	Praticidad	0	0.21	0.016	0.000	0.21	0.016	0.000
W52	Aburrido	0	0.21	0.016	0.000	0.21	0.016	0.016
TOTAL		**0.475**	**13.37**	**1**	**0.494**	**13.23**	**1**	**0.556**

Fuente: Elaboración Propia

En la Tabla 4 se muestra como las distancias son diferentes utilizando cada método, con la distancia de Hamming el valor es de 0.475, mientras que utilizando Distancia de Hamming ponderada(OWA), el resultado es de 0.494, y con Distancia (de Hamming) media ponderada ordenada (OWAD), el valor es de 0.556. Cuando las ponderaciones estan ordenadas el grado de incertidubre es mayor por tanto la distancia aumenta .

3. Aplicación del Non Monotonic

Los operadores NOMOWA, tienen pesos negativos y exhiben no monotonicidad. Si bien la monotonicidad es claramente una propiedad útil en una agregación, hay situaciones en las que la nomonotonicidad puede ser útil. Una aplicación potencial de estos operadores no monotónicos de OWA está en el dominio de la agregación multi-criterio guiada por cuantificador en la cual el cuantificador guía no es monotónico (Yager, 1999).

El autor Ovchinikov (1998) introdujo una extensión de los operadores OWA que permiten la posibilidad de tener una no monotonicidad en el proceso de agregación. Como veremos, una característica distintiva de estos operadores es que permiten que se utilicen pesos negativos en el vector de ponderación OWA.

A continuación se muestra en la tabla 5, la aplicación de herramientas no monotónicas: Distancia de Hamming ponderada no monotónica (WHD) y la distancia media ponderada ordenada no monotónica (OWAD), aplicadas al color rojo, donde la ponderación se hizo basado en la revison de la literatura de piscicologia del color para relacionar las reacciones que podrian ser extremadas por el rojo.

Tabla 5. Aplicación de herramientas no monotónicas WHD y No monotónicas OWAD

Non-Monotonic-WHD			Non-Monotonic-OWAD		
Non-Mon-WHD	**Non-Mon-WHD***	**Resultados Non-Mon-WHD**	**Non- Mon - OWAD**	**Non- Mon - OWAD***	**Resultados Non- Mon -OWAD**
0.9	0.057	0.057	1	0.063	0.063
0.45	0.029	0.029	1	0.063	0.063
0.2	0.013	0.013	1	0.063	0.057
0.33	0.021	0.019	0.9	0.057	0.051
0.55	0.035	0.031	0.9	0.057	0.051
0.85	0.054	0.048	0.9	0.057	0.051
0.9	0.057	0.051	0.9	0.057	0.046
-0.3	-0.019	-0.015	0.9	0.057	0.046
0.2	0.013	0.01	0.85	0.054	0.043
0.4	0.025	0.02	0.8	0.051	0.041
-0.2	-0.013	-0.01	0.8	0.051	0.035
0.65	0.041	0.029	0.7	0.044	0.031
0.4	0.025	0.018	0.65	0.041	0.029
1	0.063	0.044	0.5	0.032	0.022
-0.1	-0.006	-0.004	0.5	0.032	0.022
0.9	0.057	0.04	0.55	0.035	0.024
-0.4	-0.025	-0.018	0.45	0.029	0.02
0.3	0.019	0.013	0.4	0.025	0.015
-0.3	-0.019	-0.011	0.4	0.025	0.015
-0.3	-0.019	-0.011	0.4	0.025	0.015
0.25	0.016	0.01	0.4	0.025	0.015

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0.4	0.025	0.015	0.4	0.025	0.015
0.4	0.025	0.015	0.3	0.019	0.01
0.3	0.019	0.01	0.3	0.019	0.01
0.3	0.019	0.01	0.3	0.019	0.01
0.8	0.051	0.025	0.33	0.021	0.008
0.5	0.032	0.013	0.25	0.016	0.006
-0.4	-0.025	-0.01	0.2	0.013	0.005
-0.5	-0.032	-0.013	0.2	0.013	0.005
0.1	0.006	0.003	0.2	0.013	0.005
0.2	0.013	0.005	0.2	0.013	0.005
0.1	0.006	0.003	0.2	0.013	0.005
0.1	0.006	0.003	0.2	0.013	0.004
-0.1	-0.006	-0.002	0.1	0.006	0.002
0.2	0.013	0.004	0.1	0.006	0.001
0.5	0.032	0.006	0.1	0.006	0.001
-0.1	-0.006	-0.001	0.1	0.006	0.001
0.9	0.057	0.011	0	0	0
1	0.063	0.013	0	0	0
0.7	0.044	0.009	0	0	0
0	0	0	-0.1	-0.006	-0.001
1	0.063	0.006	-0.1	-0.006	-0.001
0.9	0.057	0.006	-0.1	-0.006	-0.001
0.8	0.051	0.005	-0.2	-0.013	-0.001
0.2	0.013	0.001	-0.2	-0.013	-0.001
0.2	0.013	0.001	0.3	0.019	0.002
0.4	0.025	0.003	-0.3	-0.019	-0.002
0.1	0.006	0.001	-0.3	-0.019	-0.002
0	0	0	-0.3	-0.019	-0.002
-0.2	-0.013	-0.001	-0.4	-0.025	0
0.3	0.019	0	-0.4	-0.025	0
0	0	0	-0.5	-0.032	-0.032

15.78	**1**	**0.501**	**15.78**	**1**	**0.811**

Fuente: Elaboración Propia

4. Conclusiones

En esta investigación permite conocer las demandas de la generación milenio, y descubrir la percepción que tienen ante ciertos productos y servicios, mediante la utilización de la lógica difusa, la distancia de Hamming, el promedio ponderado ordenado (OWA), el operador de distancia promedio ponderada ordenada (OWAD) y los operadores no monotónicos de NOMOWA, que ayuda a valuar las percepciones. Dado que la generación milenio tienen hasta cierto punto comportamientos imprecisos ya que debe contextualizarse el fenómeno de comportamiento al lugar geográfico y condiciones determinadas. Bajo este contexto la teoría de conjuntos borrosos permite disminuir la incertidumbre en el momento comunicarse con los millennials. Cuando los modelos matemáticos ayudan a tomar decisiones se muestran algunas ventajas como la obtención de soluciones claras y rápidas que son fáciles de comprender. La lógica borrosa no aumenta la dificultad de las matemáticas tradicionales y está más cercana al pensamiento humano (Canós, 2013).

Es importante aclarar que las distancias más cortas son las ideales, ya que muestran propiamente una leve distancia entre lo ideal y lo buscado, ante esto se puede establecer que el color rojo no es precisamente el que genera más anclaje con los millennials de acuerdo a los resultados matemáticos. Sin embargo, el color rojo se vincula con consumo, pasión, practicidad y selectividad, elementos que revelan en gran medida los gustos y preferencia de este segmento de mercado, particularmente su actitud consumista y orientada a gastar la totalidad del ingreso, ya que son materialistas y acumulativos, a causa de la cultura de consumo que les ha tocado vivir como resultado de las innovaciones tecnológicas (Valentine & Powers, 2013), así como su vinculación con las marcas generando una defensa apasionada de las marcas que los definen y con las que se identifican, así como con las que no respetan. La selectividad de los millennials incluye amigos, marcas, experiencias, etc. A la generación milenio le gustan las marcas distintivas.

Es evidente que en el proceso de entendimiento de la generación milenio, deben ser incorporadas distintas estrategias para conocer de manera más precisa los gustos y preferencias de este numeroso segmento. Esta investigación se centra en la valoración matemática de las palabras que definen al millennial y la comunicación por medio de los colores, distinguiendo la importancia de la utilización de estrategias de marketing sensorial, psicología del color y el análisis de fenómenos relacionados a la percepción por medio de lógica difusa así como nuevas herramientas de agregación no monotónicas WHD y OWAD. Dado que estas agregaciones utilizan ponderaciones negativas para casos de agregación muy radicales, este análisis representa una innovación en el estudio de la teoría del color.

Finalmente este documento puede robustecerse con futuras investigaciones donde sean analizados otros colores y su vínculo con los millennials, así como la integración de nuevas herramientas de agregación.

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A decision-support system for the reallocation of inventory to orders in LHP situations in the ceramics sector

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Abstract

Manufacturing environments with a lack of homogeneity in the product (LHP) are characterized by the fact that units of the same product can present differences in some characteristics which are important to customers. This becomes a problem when customers require homogeneous units of a single product. In such a case, only homogeneous units of the different units in stock can be allocated to the customer order. Thus, the optimal allocation of inventory to orders is made much more complex. Furthermore, in an MTS environment, different circumstances may mean than an optimal initial allocation may become les than ideal over time. This problem occurs in the ceramics sector, where the final product varies in tone and calibre. In order to address this problem, this study contains a proposal for a decision-support system (DSS), which by applying and executing a linear programming model, enables an optimal reallocation of inventory to order lines to be carried out in businesses in which LHP is inherent.

Keywords: *ERP, lack of homogeneity in the product, reallocation of inventory*

Introduction

In a make-to-stock (MTS) strategy, production planning is based on a forecast of demand (Vollmann et al, 1995). Subsequently, as real orders come in and are recorded, part of the available inventory is reserved for this order. Thus an amount of stock is allocated to the order, which then becomes unavailable for other possible uses, ensuring that the order can be fulfilled on the required date.

Optimal stock management and allocation of inventory to orders will ensure greater customer satisfaction, stock optimization, cost reductions and maximization of company turnover. However, at a particular time, this optimal allocation may become less than ideal, due to unforeseen circumstances within the company. In this case a reallocation of inventory to orders will be necessary.

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Such a circumstance may occur in any industry, but it is particularly frequent in some areas of manufacturing, in which, due to the nature of their products and/or their production processes, there is a lack of homogeneity in the product (LHP).

LHP can be defined as "a lack of the homogeneity required by the customer for a particular product" and derives from the impossibility of manufacturing homogeneous products, either in a single batch or across batches produced by means of the same process. LHP represents a problem when a particular customer acquires several units from one or more batches of the product and requires them to be homogeneous because they are to be used, displayed, placed or consumed together (Alarcón et al, 2011).

LHP is characteristic in ceramics companies, whose manufacturing processes are such they produce products with a lack of homogeneity with regard to the colours (different tones) and sizes (different calibres). Thus, the stock of a particular product is fragmented, i.e. made up of different quantities of items displaying different "tone-calibre" combinations, which must be identified, stored and managed separately.

In this industry, when processing a particular order, the product delivered must be of the same tone and calibre, as the use of different tones and calibres can lead to undesirable results: these may be aesthetic, in the case of the use of tiles of the same colour but of different tones; or functional, as the use of tiles of different calibres on floors or walls may lead to uneven surfaces.

Therefore, the correct allocation of the different tone-calibre combinations of a particular product in the inventory to each order is of great importance. The LHP present makes optimal stock allocation a much more complex task and, as a result, a decision-support system (DSS) becomes necessary.

This study examines and analyses the issue of the reallocation of stock in LHP settings by ceramics companies with orders with non-immediate delivery dates and which work to an MTS production strategy. A computerised DSS is presented here, which aims to facilitate the decision-making process.

1. State of the Art

Numerous studies have attempted to optimise the allocation of inventory to orders, focusing on two different but related concepts: ATP (available-to-promise) and inventory rationing.

Thus, ATP allocation optimisation models have been presented which maximise profits while taking penalties into account (Chen et al, 2001) and (Chen et al, 2002), there are models with different customer priorities and service strategies (Pibernik, 2005), and others consider ATP allocation in stock-out situations (Pibernik, 2006).

In Ball et al (2004) a classification of ATP systems is established in terms of different concepts, such as the mode of functioning of the system (batch-mode or real time), whether the manufacturing strategy is MTO, MTS, ATO, or whether it is pull or push, whereas in Meyr (2009) a determinist model is formulated for the ATP allocation of inventory to different "classes of customers".

It is important to note that in Ball et al (2004) the reader is warned that ATP allocation to orders may be a "myopic" view of the situation, as the orders that arrive in a particular time period have resources allocated to them without the impact that this will have on the fulfilment of future orders being taken into account. Similar comments are made in Pibernik and Yadav (2009), which provides an explanation of the problem of fulfilling orders in a system in which there is significant deviation between the forecasted and the actual demand, leading to stock-out situations when demand is higher and excess inventory when demand is weaker. The myopia of this view is also discussed in Xu et al (2009), in which an attempt is made to optimise the allocation of inventory to orders in order to minimise the number of shipments.

This situation can be remedied up to an extent by following an inventory rationing policy, as stated in Pibernik and Yadav (2009). The concept of inventory rationing involves the consideration of how inventory can be allocated to different classes of demand, and was described in Topkis (1968). Later, in Benjaafar et al (2004), different service levels and the costs of delays for the different types of customer were also taken into consideration, with a threshold being established for each class of customer, it being optimal to satisfy the demand of a given class when on-hand inventory surpasses the relevant threshold. This same article also demonstrates that inventory rationing in terms of multiple classes of customers is superior to an inventory allocation policy which fulfils orders on a first-come-first-served basis (FCFS). The concept of inventory rationing is also used in Gayon et al (2009) for the purpose of studying the optimal inventory allocation policy in production-inventory systems, with multiple customer classes, whereas in Benjaafar et al (2008), the optimal approach to inventory allocation is sought with regard to multiple inventory locations and sources of demand.

All of these studies represent attempt to allocate inventory in the best possible way, but their perspective is also a "static" one as they are based on a given situation at a company and a forecast taken at a given time, regarding available inventory, orders in the process of being manufactured, production planning, foreseen demand, etc.

However, unforeseen events in the supply chain may lead to an initially optimal inventory allocation becoming less than ideal (Vollmann et al, 1995), creating a need for the reallocation of inventory to orders Xu et al (2009). This situation is even more problematic

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in the case of multi-line orders, as the inventory must be distributed amongst the different lines of all orders for allocation to be optimal (Oltra, 2012).

Moreover, in some industries, such as the ceramics sector, the need to reallocate inventory is commonplace, even when no unforeseen events have occurred, due to the LHP problem concerning the tones and calibres of a particular product. This makes the process of allocation much more complex and the suitability of this allocation much more variable and subject to the particular circumstances of the company at a given time. This is demonstrated in Alemany et al (2013) in which a mathematical model is proposed for the management of LHP in the ceramics sector, in order to reallocate production planned at multiple plants to order lines in an optimal fashion.

The above studies propose mathematical models as DSSs and they may be of great use for management purposes, provided that their use is practical in the real world. In order for them to be of practical use, it must be possible for the mathematical model to be automated and integrated into the company's management system.

For this reason, this study presents both a mathematical model and a computer application which enables the collation of the information necessary and the integration of the mathematical model with the IT systems the company employs. The latter are typically enterprise resource planning (ERP) systems, currently the most widely used IT systems by companies (Botta et al, 2005; Grabot y Botta, 2005 and Oltra et al, 2011). Thus, a powerful DSS for the reallocation of inventory to orders in LHP situations can be made available, one which is integrated into companies' typical management systems and is therefore easy to use and implement in a real setting.

2. Description of the LHP problem in the ceramics sector

Ceramics companies manufacture their goods mainly on a make-to-stock (MTS) basis, for reasons which include the considerable setup times involved and technological considerations which demand that a minimum amount of product must be manufactured in order to ensure a particular level of homogeneity. In general, in companies of this type, customer orders are made up of several order lines in which quantities of different products are requested. When a customer makes an order inquiry to such a company, normally the Sales Department checks the availability of the requested products. If there is sufficient stock available for the date requested by the customer, the corresponding reservation can then be made (ATP allocation of the order), with a commitment thus being established with the customer.

However, this ATP allocation of an order, initially feasible because the on-time delivery of all the agreed-to orders is possible, may later become impracticable for various reasons (Alarcón et al, 2011). This is a particularly critical situation for the ceramics sector due to

LHP, which leads to the appearance of discrepancies between the planned quantities and those that are actually produced. The problems that LHP causes in ceramics companies principally concern the tone and calibre of the products manufactured (although it can also affect their surface appearance and flatness, according to Poyatos et al, 2010). In order for the customer to receive a homogeneous product and thus be able to use, place or display different product units together without any undesirable aesthetic effects, the products must be classified according to the tones and calibres they possess. Thus, a planned production of a batch of a single type of product may result in several combinations of tones and calibres being produced (sub-batches) which should not be mixed when allocating inventory to a single order line. This restriction on order fulfilment may mean that some inventory reserves which had been allocated to particular order lines may ultimately prove to be insufficient, as the number of homogeneous units produced is fewer than expected.

The reallocation of inventory to orders may help to resolve this situation. Reallocation involves seeking another manner of allocating products to orders in a way which enables one or more of the following objectives to be achieved: maximisation of profit, compliance with agreed delivery dates, more efficient use of current or future inventory, or lower costs.

In ceramics companies, however, the performance of this reallocation is made much more complex due to the LHP issue. The first reason for this is that any reallocation must ensure that products of different tones and calibres (sub-types) are not mixed together in the same order line, and yet, in order to fulfil an order, all of the order lines must be fulfilled. The second reason is that LHP has a fragmenting effect on the inventory, in the sense that a batch of a certain size, in which the tone and the calibre should be exactly the same for that particular product, may need to be broken up into two or more sub-batches of a smaller size, according to the different combinations of tone and calibre ultimately present (Segura et al, 2004 and Tortajada et al, 2006), which means that there are more possibilities to consider when considering how to fulfil orders. Logically, the complexity of the problem will increase in proportion to the number of orders received at the time of the reallocation, the number of order lines for each order, and the number of products and different sub-types involved in the inventory reallocation. This increasing complexity justifies the use of a DSS, such as the mathematical programming model presented in the next section.

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3. Mathematical model

This section presents a mathematical model which enables inventory to be reallocated. The model was presented in Oltra-Badenes (2012). The objective of the model is to optimise the allocation of inventory to orders, maximising the total sales value of the orders to be fulfilled and attempting to fulfil the orders with the earliest delivery dates.

In the model, two concepts are used: the "planning horizon" and the "delivery horizon". The planning horizon refers to the period of time within which the delivery dates of the orders to be considered in the mathematical model fall. The delivery horizon concerns a shorter period of time, in which the delivery of orders is imminent; those orders whose due date for delivery falls within this period must be prepared in the warehouse without delay so that they can be sent out. The model prioritizes the allocation of inventory to orders whose delivery date is within the delivery horizon, given that these orders must be dealt with urgently in the warehouse.

The mathematical model described below is made up of indices, sets, parameters, decision variables, an objective function and restrictions.

Indices

- i order
- l order line
- k product
- b sub-batch (each particular combination of a tone and a calibre).

Sets

- I Set of orders which are within the planning horizon h.
- $I(h_e)$ Set of orders whose delivery dates are within the delivery horizon he.
- L(i) Set of order lines l, which contain k and form part of order i.
- B(k) Set of sub-batches of product k

Parameters

- p_1 Specific weight given to the sales value of the order in the objective function.
- p_2 Specific weight given to the delivery date in the objective function.
- b_i Total sales value of order i.
- h Planning horizon (expressed in days).

h_e Order delivery horizon (expressed in days).

f_{ei} Delivery date of order i, expressed in days remaining from the moment at which the model is implemented.

$n_{I(he)}$ Number of orders whose delivery dates are within the delivery horizon (he).

nli Number of order lines in order i.

d_{kil} Requested quantity of product k, in line l of order i.

q_{kb} Quantity of product k and sub-batch b present in the warehouse.

b_{max} Maximum order value (Maximum of the bi).

b_{min} Minimum order value (Minimum of the bi).

ε Positive value, small and lower than 1. This value is used in order to avoid the possibility that a term in the objective function has a value of zero (for example, 0.001).

Decision variables

Y_i Binary variable indicating whether the order has been completely reserved (i.e. all its lines L(i) are reserved). If this is the case, the value will be taken to be (1) and, if not, the value will be taken as (0).

U_{kilb} Binary variable indicating whether the line (l) of the order (i) has a product (k) and a sub-batch (b) reserved. If this is the case the value will be taken to be (1) and, if not, the value will be taken as (0).

$ATPO_{kb}$ Quantity of on-hand stock of the product (k) and sub-batch (b), which is unreserved and available to promise.

Objective function

$$Max[z] = p_1 \sum_i \left(\frac{b_i - b_{\min} + \varepsilon}{b_{\max} - b_{\min}} \right) \cdot Y_i + p_2 \sum_i \left(\frac{h - fe_i + \varepsilon}{h} \right) \cdot Y_i \quad (1)$$

The first term of the objective function maximises the sales value, while the second minimises the sum of the days remaining for the delivery of all of the orders. There are two weighting factors (p1 and p2), which enable greater weight to be given to one objective or the other.

The magnitudes of the two terms of the objective function are very different, so the equations presented in this study have been employed in order to bring the two factors within a comparable range.

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Restrictions

$$\sum_{i \in I(h_e)} Y_i = n_{I(h_e)} \tag{2}$$

Restriction (2) ensures that all of the orders in the delivery horizon will be completed, i.e. material will be reserved in order to fulfil all of its order lines.

This may not be feasible. In that case, this restriction must be eliminated in order to obtain an optimal result, but not all of the orders will be completed.

$$\left(nl_i - \sum_k \sum_{l \in L(i)} \sum_{b \in B(k)} U_{kilb} \right) \leq (1 - Y_i) \cdot nl_i \;\; ; \; \forall i \tag{3}$$

Restriction (3) ensures that only the completed orders, i.e. those which have material reserved for each and every one of its order lines, will be taken into account in the objective function.

$$\sum_i \sum_{l \in L(i)} d_{kil} \cdot U_{kilb} + ATP0_{kb} = q_{kb} \;\; ; \;\; \forall k, b \in B(k) \tag{4}$$

Restriction (4) ensures the continuity of inventory, so that the sum of the quantities allocated to the different order lines of product k and sub-batch b, together with the unreserved on-hand stock of that product and sub-batch, is never higher than the quantity of product k and sub-batch b actually present in the warehouse.

$$\sum_{b \in B(k)} U_{kilb} \leq 1 \; ; \;\; \forall i, l \in l(i), k \tag{5}$$

Restriction (5) limits to 1 the number of sub-batches that can be reserved for an order line.

$$U_{kilb}, Y_i \in \{0,1\} \; ; \;\; \forall k, i, l, b \tag{6}$$

Restriction (6) determines the decision variables as binary variables U_{kilb} and Y_i.

$$ATP0_{kb} \geq 0 \; ; \; \forall k, b \tag{7}$$

Finally, restriction (7) indicates that the on-hand stock of product k and sub-batch b can never be negative.

4. Decision Support System

In order to facilitate the use of the mathematical model in a real setting, a system was developed which is able to import data from the company's management application (generally an ERP system (Botta-Genoulaz and Millet, 2005; Gil et al., 2010)), transform the data into the appropriate format for the execution of the mathematical model, display the results and export them to the management application.

In order to carry out this process, a six-step assistant was created. A description of each of the assistant's six steps is given below.

- **Step 1: Importing the external data**

The first step is to extract the data from the company's system (generally an ERP) and these are introduced into the assistant's tables. The extraction is undertaken using an Open DataBase Connectivity (ODBC) connection, a standard interface with which to access database management systems (DBMSs) and which was developed by SQL Access Group in 1992. This makes it possible to access any data from any application, regardless of the DBMS which stores the data.

Obviously, every time the system is implemented, the OBDC connection must be optimised for the application that the company uses. The data that must be imported are those referring to:

  - Order headers
  - Order lines
  - Stock situation

All of the data imported are stored in tables specifically designed for this purpose in the DSS.

- **Step 2: Transforming the data into MPL format**

Generally, when attempting to implement the mathematical model, the data imported from the management system used by the company will not be in the format required for the mathematical model. A process through which to transform the data into the correct format is therefore needed. The second step of the process concerns this data formatting, using Visual Basic, by means of which the data imported in Step 1 are transformed (having been stored in the imported data tables), and the data are generated in new tables, which are in the ideal format for use in the mathematical model.

The assistant employs a macro written in Visual Basic for this purpose and it carries out various elimination and update queries in the appropriate tables. The result is a set of tables containing the data required and in a format that can be used by the MPL program to execute the mathematical model presented in this study.

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- **Step 3: Executing the Mathematical Model in MPL**

The mathematical model is executed using the MPL Modeling System program, version 4.2K, 64 bits. The solver used to implement the model in was the Gurobi program, version 4.0.1, also 64 bits.

- **Step 4: Viewing the results**

In the fourth step, the results obtained from the model can be viewed, along with the orders and order lines that will be fulfilled and the resulting stock situation.

- **Step 5: Taking a decision**

After viewing the results, the fifth step concerns taking the appropriate decisions, or, alternatively, the modification of a particular parameter and the model can then be executed once more. For example, modifications could be made to parameters p1 and p2, which determine the relative weight of the sales value and the days remaining until delivery, as components of the objective function of the mathematical model.

- **Step 6: Exporting the Results to an External Application**

Once the decisions have been taken, the only remaining task is to export the data to the company's management system. To do this, an ODBC connection is established which transfers the data obtained from the optimization which are contained in the appropriate tables to the tables of the ERP system or another system which the company uses. A prior conversion of the data into the appropriate format must take place. This can be undertaken using a macro written in Visual Basic.

5. Conclusions

LHP is characteristic of the ceramics industry, where the manufacturing process generates products which possess a lack of homogeneity with regard to tone and calibre. However, a single customer order must be fulfilled with homogeneous products. Therefore, the correct allocation of the different tone-calibre combinations of a product held in the inventory to the different sales orders received is of high importance, greatly increasing the complexity of the allocation of inventory to orders. Moreover, the presence of LHP may mean that what at one time may have been an optimal inventory allocation may becomes less than ideal, making an inventory reallocation necessary. This creates a problem which is difficult to manage, leading to the need for the use of mathematical models and a DSS.

In this study, the problems caused by LHP for the allocation of inventory to orders in the ceramics sector have been described. This problem can be solved with a mathematical model However, in the real world, the formulation of a mathematical model is not

sufficient. In order for it to be useful, it must be possible for it to be executed easily and for it to be integrated into companies' IT systems. To this end, this article has presented a DSS which enables the use of the mathematical model in a real setting. The DSS can be integrated into the IT systems companies' use, such as ERP systems. In this way, a powerful DSS system with the ability to reallocate inventory to orders in LHP situations has been obtained. Furthermore, the proposed DSS is capable of finding optimal solutions which make it possible for both income per sale and the ratio of order fulfilment to be improved, in comparison with the usual method of allocation, which is usually performed on a FCFS basis.

Future lines of research could include the study of the effects of size on order lines and sub-batches, on reallocation efficiency, and on the number and size of the remaining items of sub-batches present in the warehouse. The study of LHP could also be extended to other business areas, such as in forecast calculations, stock management or production management.

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A bibliometric analysis of venture capital research

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Abstract

Purpose. The aim of this study is to present the evolution of academic research in venture capital research between 1990 and 2014.

Design/methodology/approach. The study analyzes the most influential journals in Venture Capital research by analyzing papers, which were published on the Web of Science database.

Findings. Results show a steadily increasing rate of venture capital research during the last 25 years. We report the 40 academic journals that permanently publish articles about venture capital research.

Originality/value. The main contribution of this work is to develop a general overview of the leading journals in Venture Capital research, which leads to the development of a future research agenda for bibliometric analysis, such as the review of the most productive and influential authors, universities, and countries in venture capital research.

Keywords: *Venture Capital; Bibliometrics; Journals, Web of Science.*

Introduction

There are different instruments, both public and private, which support the development and growth of new enterprises through the provision of financial resources. Venture Capital (VC) is included among these instruments, which not only provides financial support for business growth, but also offers business expertise, customer networks and good management practices (Gompers and Lerner, 2006; Gompers et al., 2008; Dushnitsky and Lenox, 2006; Hochberg et al., 2010). According to Cornelius and Persson (2006), venture capitalists are financial intermediaries who collect excess capital from those who have it, and provide it to those who require it for the development of a business venture. Although a considerable amount of literature has been published on specific topics about VC in the last 10 years (Jääskeläinen, 2012), there are few studies that have analyzed VC research from a bibliometric analysis perspective (Cornelius and Persson, 2006). In this decade, there are no new papers that present the evolution of venture capital research. This is the aim of our paper.

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We found a practical way to analyze venture capital research over a period of 25 years by using bibliometric indicators. Bibliometrics is the field that quantitatively studies bibliographic material (Broadus, 1987). Bibliometric studies are becoming very popular in the scientific literature, strongly motivated by the access to bibliographic information. Many authors have developed bibliometric analysis in a wide range of fields including: management (Podsakoff et al. 2008), economics (Coupé, 2003), entrepreneurship (Landström, 2012), accounting (Merigó and Yang, 2016), pricing research (Leone et al. 2012), health economics (Wagstaff and Culyer, 2012) and innovation (Merigó et al., 2016a).

In general, venture capital research has grown considerably in proportion to other disciplines. The citation structure identifies the citation level that this field has obtained, being able to see the location of the most cited papers over the last twenty-five years. Additionally, it shows the number of papers with lower levels of citations including those that have not received any citations yet. The article also develops a journal analysis identifying the leading ones in the field. In particular, we note that there are certain specialized journals that publish more in venture capital research with respect to other journals, for example, Journal of Business Venturing, Entrepreneurship Theory and Practice, and Small Business Economics. It also highlights other journals for having a high number of citations, even if they publish a large number of articles in VC research, such as the Journal of Finance, Journal of Financial Economics, Research Policy, Strategic Management Journal, Academy of Management Journal, Administrative Science Quarterly, among others. Moreover, a temporal analysis is developed in order to see which journals have been the most influential ones throughout time.

The remainder of the paper is organized as follows: Section 2 develops the literature review regarding VC research. Section 3 describes the research method by describing the bibliometric study and its cluster analysis. Section 4 presents the results of our bibliometric analysis. Finally, Section 5 offers a discussion with concluding remarks.

1. Literature review

Gompers and Lerner (2006) define VC as the process which starts with raising a venture fund; proceeds with investing in, monitoring, and adding value to firms; continues as the venture capitalist exits successful deals and returns capital to their investors; and renews itself with the venture capitalist raising additional funds. Hence, VC research explores several processes, which involve the pre-investment phase of VC, the management of VC, and the exit strategies of VC. In the pre-investment phase, VC research explores how changes in public market signals affected venture capital (Gompers et al., 2008), or the conditions to facilitate the creation of greater firm value after receiving VC (Dushnitsky and Lenox, 2006). Research in this stage also analyses the process of creating relationships

between venture capitalists and entrepreneurs (Hochberg et al., 2010). Research in the management stage focused its attention on companies when they receive venture capital. For examples, researchers have explored the links between the influence and control of VC firms (Bottazzi, Da Rin & Hellmann, 2008) and the management skills and expertise of entrepreneurs and new ventures, such as entrepreneurial orientation (Stam & Elfring, 2008). Finally, research in the exit stage reviews how firms can develop either their initial public offering (IPO) or their buyout. Nahata (2008) suggests that companies backed by more reputable VCs by initial public offering (IPO) capitalization share, are more likely to exit successfully, access public markets faster, and have higher asset productivity at IPOs.

Even though VC research has three stages of analysis, VC research encompasses wide range of academic areas, without a particular discipline leading scientific research in this field. Academics from disciplines such as Finance, General Management, Innovation, Law, Public Policy, Sociology and Economics present a wide range of research on venture capital, which is very valuable because it brings different perspectives to analyze the problem of financing new businesses. For example, from a Finance perspective, Berger and Udell (1998) explain that firms are viewed through a financial growth cycle paradigm in which different capital structures are optimal at different points in the cycle. They show the sources of small business finance, and how capital structure varies with firm size and age. From a Psychology perspective, Krueger, Reilly and Carsrud (2000) argue that promoting entrepreneurial intentions by promoting public perceptions of feasibility and desirability is not just desirable; but also thoroughly feasible. From a Sociology perspective, Podolny (2001) draws an analytical distinction between two types of market uncertainty: egocentric, which refers to a focal actor's uncertainty regarding the best way to convert a set of inputs to an output desired by a potential exchange partner, and altercentric, which denotes the uncertainty confronted by a focal actor's exchange partners regarding the quality of the output that the focal actor brings to the market. From a Public Policies perspective, Di Gregorio and Shane (2003) provide insight into why some universities generate more new companies to exploit their intellectual property than do others. The above examples show that the analysis of venture capital research is varied and can derive from different disciplines. On the one hand, it could be positive to have different perspectives to try to understand the problem. On the other hand, analysis from different disciplines could be negative, especially if we want to know the specific group of authors in venture capital research who have more influence and productivity.

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2. Research Methodology

Bibliometric research is a field that quantitatively studies bibliographic material (Broadus, 1987) providing a general overview of a research field according to a wide range of indicators. There are different ways of ranking material in a bibliometric analysis. The most common approaches use the total number of articles or the total number of citations. Another useful indicator is the h-index (Hirsch, 2005) that combines articles with cites indicating the number of studies X that have received X or more citations. The general assumption is that the number of articles shows the productivity while the total cites reflects the influence of a set of articles. Note that this study follows the methodology developed by Merigó et al. (2015a; 2015b).

In order to search for articles that have focused on venture capital research, the study uses the keywords "venture capital*" or "business venturing" or "corporate venturing" in the title, abstract and keywords of any work available in WoS[1] between 1990 and 2014, in order to capture as many possible combinations of terms related to venture capital. This search finds 2,086 articles that have become 1,820 studies by only considering articles, reviews, letters and notes. The search was developed in October 2015 and January 2016.

3. Results

This section presents the results of the paper. First, the study analyzes the publication evolution of venture capital research during the last twenty-five years. Next, the work analyzes the citation structure indicating the number of articles that reach a specific citation threshold. Finally, the article analyzes the most influential journals in venture capital research according to WoS (general analysis and by quinquennials).

Publication evolution in venture capital research

Over the last twenty-five years, 1,820 articles have been published in venture capital research. Figure 1 presents the evolution of the number of papers published annually.

[1] Web of Science (WoS) is one of the most popular databases for classifying scientific research worldwide. The assumption is that it only includes those journals that are evaluated with the highest quality.

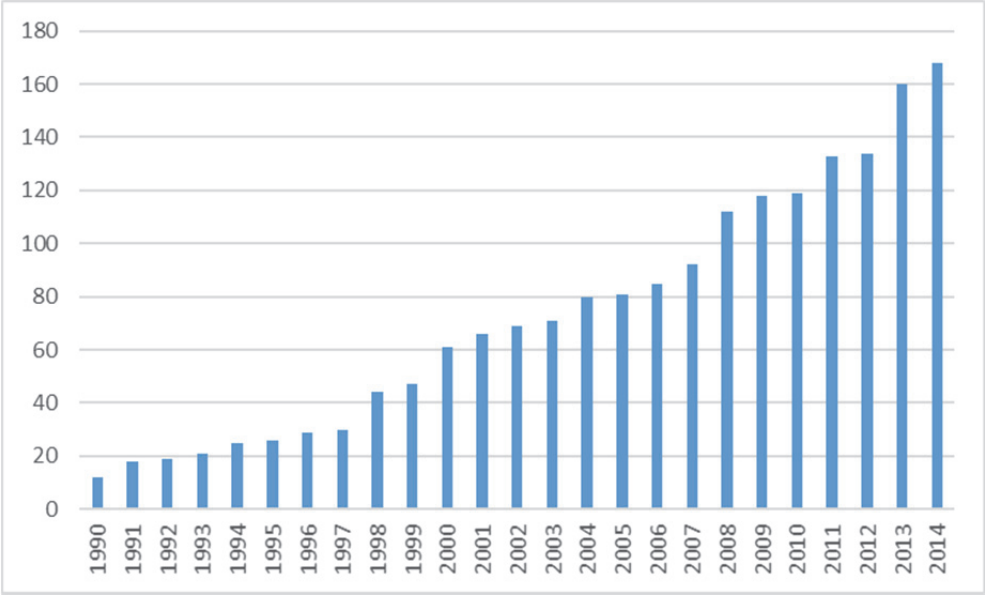

Fig.1 Annual number of studies in venture capital

In general, the growth of venture capital research over the last twenty-five years is higher than the growth of science worldwide. This growth is usually between 5% and 10%, and achieved over 20% in 1991, 1998, 2000, and 2008.

Citation structure in venture capital research

Table 1 presents the number of articles that reach a certain citation threshold in order to see the citation level that venture capital articles obtain. The analysis was developed between 1990 and 2014 and considers the citation thresholds of 200, 100, 50, 20, 10, 5 and 1. The total number of cites obtained by papers published each year is also included.

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Table 1. Citation structure of venture capital

Year	≥200	≥100	≥50	≥20	≥10	≥5	≥1	TC	TP
1990	2	2	3	5	7	7	7	1041	12
1991	1	1	1	5	7	7	11	718	18
1992	0	1	7	12	12	14	16	782	19
1993	0	1	4	6	7	9	15	439	21
1994	3	7	10	16	18	19	23	1926	25
1995	2	2	7	13	14	17	20	1118	26
1996	1	6	7	10	14	17	24	1146	29
1997	0	1	7	15	20	21	25	860	30
1998	4	10	15	22	27	31	41	3281	44
1999	3	5	10	17	17	21	26	2104	47
2000	3	7	13	20	23	29	41	2362	61
2001	4	7	14	27	32	36	46	3005	66
2002	4	7	18	31	37	44	54	3010	69
2003	5	13	30	42	51	56	69	4320	71
2004	2	11	21	35	42	50	56	2951	80
2005	1	7	17	49	58	63	73	3095	81
2006	0	2	17	38	55	63	78	2223	85
2007	1	4	11	47	70	89	103	2712	92
2008	0	0	15	31	47	64	75	1929	112
2009	0	0	7	31	59	79	106	1818	118
2010	0	0	5	26	48	78	106	1546	119
2011	0	1	2	22	49	73	110	1397	133
2012	0	1	2	9	35	61	107	1063	134
2013	0	0	0	2	13	45	119	575	160
2014	0	0	1	3	10	19	99	414	168
Total	*36*	*96*	*244*	*534*	*772*	*1012*	*1450*	*45835*	*1820*
%	*2%*	*5%*	*13%*	*29%*	*42%*	*56%*	*80%*		

Source: Own

As we can see, most of the highly cited studies in venture capital were published in the late nineties and beginning of the new millennium. The number of articles published in venture capital increases every year so the number of highly cited works also tends to increase. In general, only 2% of the articles have received more than 200 and more than half of the articles received at least five citations. Only 20% of the work did not receive any citations. Among the most cited papers it is possible to identify the following articles in venture

capital research: Stuart et al. (1999), Zucker at al. (1998), Sahlman (1990), Megginson and Weiss (1991), Powell et al. (2005), Krueger et al. (2000), Berger and Udell (1998), Lee et al. (2001), Sorenson and Stuart (2001), McDougall et al. (1994), Shane and Stuart (2002), Kaplan and Stromberg (2003) and Podolny (2001).

Leading journals in venture capital research

There are many journals in the scientific community that publish material related to venture capital research. Table 2 presents a list of the twenty journals with the highest h-index in venture capital research (HV). We performed the ranking analysis by identifying the rank (R), the total number of publications in venture capital research (TPV), the total number of citations in venture capital research (TCV), the total number of citations over the total number of publications in venture capital research (C/P1), the total number of publication of the journal (TP), the total number of citation of the journal (TC), the global h-index (H); the total number of citations over the total number of publications (C/P2), and the total number of publications in venture capital research over the total number of publications in any discipline (%PV).

Table 2. Most influential journals in venture capital

R	Journal	Venture Capital				Global				%PV
		TPV	TCV	HV	C/P1	TP	TC	H	C/P2	
1	Journal of Business Venturing	164	6976	48	42,5	836	36562	98	43,7	19,6%
2	Journal of Finance	23	2923	21	127,1	1972	170112	199	86,3	1,2%
3	Journal of Financial Economics	35	2884	21	82,4	1791	106449	153	59,4	2,0%
4	Entrepreneurship Theory and Practice	49	1070	21	21,8	515	15361	62	29,8	9,5%
5	Research Policy	37	1609	20	43,5	2059	87374	141	42,4	1,8%
6	Small Business Economics	67	833	16	12,4	1252	21557	63	17,2	5,4%
7	Strategic Management Journal	25	1477	15	59,1	1726	179035	202	103,7	1,4%
8	Journal of Management Studies	23	624	14	27,1	1252	47442	101	37,9	1,8%
9	Journal of Banking Finance	25	1024	13	41,0	3561	49728	78	14,0	0,7%
10	Journal of Corporate Finance	35	569	13	16,3	723	8678	43	12,0	4,8%
11	Technovation	30	396	13	13,2	1538	24024	59	15,6	2,0%
12	Academy of Management Journal	19	916	11	48,2	1490	180389	218	121,1	1,3%
13	Review of Financial Studies	26	763	10	29,3	1377	60715	116	44,1	1,9%
14	Harvard Business Review	26	634	10	24,4	4847	65716	113	13,6	0,5%
15	Management Science	14	966	9	69,0	3247	151121	166	46,5	0,4%
16	Entrepreneurship and Regional Development	18	300	9	16,7	381	5525	35	14,5	4,7%
17	Administrative Science Quarterly	8	1050	8	131,3	512	102142	168	199,5	1,6%

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R	Journal	Venture Capital				Global				%PV
		TPV	TCV	HV	C/P1	TP	TC	H	C/P2	
18	Organization Science	16	613	8	38,3	1301	113095	154	86,9	1,2%
19	Financial Management	14	494	8	35,3	832	10680	47	12,8	1,7%
20	Journal of International Business Studies	11	260	8	23,6	1162	61441	121	52,9	0,9%
21	R D Management	13	231	8	17,8	781	13961	54	17,9	1,7%
22	Journal of Financial Intermediation	13	185	8	14,2	395	7486	43	19,0	3,3%
23	Journal of Small Business Management	17	184	8	10,8	622	10391	47	16,7	2,7%
24	Regional Studies	10	311	7	31,1	1805	29878	68	16,6	0,6%
25	Journal of Financial and Quantitative Analysis	11	182	7	16,5	958	22384	73	23,4	1,1%
26	European Planning Studies	16	148	7	9,3	1174	8769	36	7,5	1,4%
27	European Financial Management	10	104	7	10,4	340	2706	24	8,0	2,9%
28	California Management Review	10	260	6	26,0	730	30914	86	42,3	1,4%
29	Journal of Business Finance Accounting	12	135	6	11,3	533	3446	24	6,5	2,3%
30	International Journal of Technology Management	32	131	6	4,1	1810	9342	33	5,2	1,8%
31	Strategic Entrepreneurship Journal	17	126	6	7,4	155	2502	26	16,1	11,0%
32	Journal of Technology Transfer	13	118	6	9,1	322	2295	22	7,1	4,0%
33	Journal of Business Research	14	99	6	7,1	3214	53711	87	16,7	0,4%
34	Industrial and Corporate Change	10	95	6	9,5	598	12070	53	20,2	1,7%
35	Health Affairs	8	56	6	7,0	5495	92245	108	16,8	0,1%
36	Journal of Management	7	484	5	69,1	1100	80900	135	73,5	0,6%
37	Journal of Economics Management Strategy	13	200	5	15,4	672	10496	51	15,6	1,9%
38	Accounting Review	6	150	5	25,0	1167	34321	82	29,4	0,5%
39	International Small Business Journal	12	119	5	9,9	371	4090	28	11,0	3,2%
40	Corporate Governance An International Review	11	62	5	5,6	606	6798	34	11,2	1,8%

It is seen that only the first journal publishes about 20% of its total articles on venture capital, only one publishes about 10%, 3 publish about 5%, and the rest does not publish more than 2%. However, these have high numbers of citations, which explains the results of the h-index. Clearly, scientific analysis on venture capital comes from many disciplines, and it is not possible to identify a specific group of journals leading the discipline. This is evident if the group of the twenty most cited papers in venture capital research is analyzed. For this group it is possible to identify 12 different journals: Administrative Science Quarterly, American Economic Review, American Journal of Sociology, Journal of Banking & Finance, Journal of Business Venturing, Journal of Finance, Journal of

Financial Economics, Management Science, Rand Journal of Economics, Research Policy, Review of Economic Studies and Strategic Management Journal. Among this group, three journals (Journal of Financial Economics, Journal of Finance and American Journal of Sociology) present three articles each on the list of the 20 most cited papers in venture capital research.

Leading journals in venture capital by periods of time

In this section, let us focus on the evolution of leading journals in innovation research throughout time. In order to do this, the study considers five-year periods between 1990 and 2014. In each period, a list with the journals that have published the highest number of articles in venture capital is presented. The analysis uses similar indicators to Table 2. Tables 3, 4, 5 and 6 present the results (period 2000-2004 was omitted in this version of the paper).

Journal of Business Venturing and Journal of Financial Economics have been the main leaders during the last twenty-five years. In the nineties, there were not many specialized journals in venture capital indexed in WoS. Since 2005, journals with the highest proportion of venture capital items over total publications have appeared.

In the first five-year period analyzed it is possible to see that academic papers in venture capital research are published mainly in journals of General Management and Finance. In the second quinquennial, in addition to journals of General Management and Finance, several papers were published in specialized journals in Innovation and Entrepreneurship research. In the last quinquennial, Table 6, it is possible to see that there are several journals, from a wide spectrum of disciplines, publishing papers in venture capital research.

Table 3. Leading journals in venture capital between 1990-1994

R	Journal	TPV	TCV	HV	C/P1	TP	TC	H	C/P2
1	Journal of Business Venturing	29	1.543	20	53,2	149	8.551	55	57,4
2	Journal of Financial Economics	3	1.091	3	363,7	154	18.034	65	117,1
3	Financial Management	3	418	3	139,3	254	3.661	30	14,4
4	Harvard Business Review	3	72	2	24,0	900	19.538	63	21,7
5	Technovation	3	30	2	10,0	180	1.400	19	7,8
6	Journal of Finance	2	703	2	351,5	417	42.723	104	102,5
7	Academy of Management Journal	2	286	2	143,0	268	42.520	119	158,7
8	Strategic Management Journal	2	162	2	81,0	300	45.300	114	151,0
9	Long Range Planning	2	42	1	21,0	397	3.295	29	8,3
10	Organization Science	1	96	1	96,0	141	31.823	70	225,7
11	Management Science	1	45	1	45,0	575	35.956	99	62,5

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R	Journal	TPV	TCV	HV	C/P1	TP	TC	H	C/P2
12	Journal of Management Studies	1	19	1	19,0	175	8.395	49	48,0
13	California Management Review	1	15	1	15,0	152	6.339	38	41,7
14	Health Affairs	1	4	1	4,0	549	6.947	37	12,7
15	Journal of Portfolio Management	1	0	0	0,0	259	1.940	19	7,5
16	Administrative Science Quarterly	0	0	0	0,0	113	40.473	90	358,2
17	Journal of Management	0	0	0	0,0	196	23.883	85	121,9
18	Review of Financial Studies	0	0	0	0,0	142	14.424	67	101,6
19	Journal of International Business Studies	0	0	0	0,0	167	12.182	62	72,9
20	Research Policy	0	0	0	0,0	174	8.379	46	48,2
21	Accounting Review	0	0	0	0,0	235	6.256	46	26,6
22	Journal of Product Innovation Management	0	0	0	0,0	120	6.059	45	50,5
23	Journal of Financial and Quantitative Analysis	0	0	0	0,0	177	5.155	42	29,1
24	Journal of Law & Economics	0	0	0	0,0	121	5.081	39	42,0
25	Journal of Business Research	0	0	0	0,0	257	5.535	38	21,5
26	Journal of Banking Finance	0	0	0	0,0	315	5.533	38	17,6
27	Regional Studies	0	0	0	0,0	276	4.650	34	16,8
28	Chimia	0	0	0	0,0	450	3.406	28	7,6
29	Ieee Transactions On Engineering Management	0	0	0	0,0	197	2.688	26	13,6
30	R D Management	0	0	0	0,0	126	2.312	26	18,3
31	Small Business Economics	0	0	0	0,0	90	1.417	20	15,7
32	Journal of Economics Management Strategy	0	0	0	0,0	68	1.200	17	17,6
33	Research Technology Management	0	0	0	0,0	238	1.155	17	4,9
34	International Journal of Technology Management	0	0	0	0,0	56	306	9	5,5
35	Technology Analysis Strategic Management	0	0	0	0,0	30	160	6	5,3
36	Journal of Technology Transfer	0	0	0	0,0	6	2	1	0,3
37	Entrepreneurship Theory and Practice	0	0	0	0,0	0	0	0	0,0
38	Journal of Corporate Finance	0	0	0	0,0	0	0	0	0,0
39	Entrepreneurship and Regional Development	0	0	0	0,0	0	0	0	0,0
40	Journal of Financial Intermediation	0	0	0	0,0	0	0	0	0,0

Table 4. Leading journals in venture capital between 1995-1999

R	Journal	TPV	TCV	HV	C/P1	TP	TC	H	C/P2
1	Journal of Business Venturing	24	1.481	20	61,7	131	8.107	51	61,9
2	Small Business Economics	10	228	8	22,8	215	5.116	36	23,8
3	Journal of Banking Finance	8	752	6	94,0	391	9.011	48	23,0
4	Journal of Management Studies	6	139	5	23,2	188	6.691	47	35,6
5	Technovation	6	109	5	18,2	256	3.643	41	14,2
6	Harvard Business Review	5	253	5	50,6	688	20.775	70	30,2
7	Journal of Financial Economics	3	653	3	217,7	249	26.749	90	107,4
8	Journal of Finance	3	568	3	189,3	371	49.983	122	134,7
9	Journal of Law & Economics	2	168	2	84,0	120	4.075	39	34,0
10	Research Policy	2	61	2	30,5	279	16.886	70	60,5
11	International Journal of Technology Management	4	4	1	1,0	530	3.183	23	6,0
12	Long Range Planning	2	9	1	4,5	368	4.881	32	13,3
13	Administrative Science Quarterly	1	730	1	730,0	124	35.632	91	287,4
14	Academy of Management Journal	1	133	1	133,0	279	53.250	126	190,9
15	Management Science	1	130	1	130,0	656	39.825	102	60,7
16	Review of Financial Studies	1	117	1	117,0	175	11.199	59	64,0
17	R D Management	1	113	1	113,0	132	2.293	26	17,4
18	California Management Review	1	72	1	72,0	155	13.695	57	88,4
19	Regional Studies	1	37	1	37,0	341	6.884	40	20,2
20	Health Affairs	1	18	1	18,0	708	14.189	57	20,0
21	Journal of Business Research	1	10	1	10,0	341	9.294	92	27,3
22	Journal of Small Business Management	1	2	1	2,0	171	3.128	33	18,3
23	Advances In Strategic Management A Research Annual	1	2	1	2,0	23	212	9	9,2
24	Journal of Portfolio Management	1	1	1	1,0	235	1.702	20	7,2
25	Strategic Management Journal	0	0	0	0,0	310	55.319	116	178,4
26	Organization Science	0	0	0	0,0	218	28.238	93	129,5
27	Journal of International Business Studies	0	0	0	0,0	195	14.909	71	76,5
28	Journal of Management	0	0	0	0,0	189	15.815	70	83,7
29	Journal of Product Innovation Management	0	0	0	0,0	141	8.608	52	61,0
30	Journal of Financial and Quantitative Analysis	0	0	0	0,0	135	5.385	43	39,9
31	Accounting Review	0	0	0	0,0	130	7.589	39	58,4
32	Ieee Transactions On Engineering Management	0	0	0	0,0	187	3.997	35	21,4
33	Chimia	0	0	0	0,0	504	4.550	32	9,0
34	Journal of Economics Management Strategy	0	0	0	0,0	120	2.903	30	24,2
35	Financial Management	0	0	0	0,0	150	2.137	27	14,2
36	Technology Analysis Strategic Management	0	0	0	0,0	141	2.596	25	18,4
37	Journal of Financial Intermediation	0	0	0	0,0	70	1.744	24	24,9
38	Research Technology Management	0	0	0	0,0	210	1.957	22	9,3
39	Economic Development Quarterly	0	0	0	0,0	145	1.423	20	9,8
40	Entrepreneurship Theory and Practice	0	0	0	0,0	0	0	0	0,0

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Table 5. Leading journals in venture capital between 2005-2009

R	Journal	TPV	TCV	HV	C/P1	TP	TC	H	C/P2
1	Journal of Business Venturing	44	1.530	25	34,8	185	7.896	51	42,7
2	Entrepreneurship Theory and Practice	32	973	20	30,4	234	10.276	55	43,9
3	Research Policy	14	753	13	53,8	550	23.611	78	42,9
4	Journal of Financial Economics	12	535	10	44,6	458	24.741	83	54,0
5	Small Business Economics	17	210	9	12,4	282	6.773	44	24,0
6	Journal of Corporate Finance	11	286	8	26,0	211	4.345	35	20,6
7	Technovation	12	174	7	14,5	458	10.467	50	22,9
8	Journal of Financial Intermediation	7	162	7	23,1	112	1.755	23	15,7
9	Entrepreneurship and Regional Development	7	157	6	22,4	122	2.186	26	17,9
10	Journal of Business Finance Accounting	7	121	6	17,3	297	2.756	23	9,3
11	Strategic Management Journal	6	326	6	54,3	336	23.028	85	68,5
12	Journal of Management Studies	6	262	6	43,7	313	13.248	64	42,3
13	Journal of Banking Finance	6	141	6	23,5	913	16.012	50	17,5
14	Journal of Technology Transfer	6	107	6	17,8	107	1.279	19	12,0
15	European Planning Studies	11	78	5	7,1	369	3.686	27	10,0
16	Journal of Finance	5	523	5	104,6	332	21.160	83	63,7
17	Academy of Management Journal	5	370	5	74,0	298	28.004	95	94,0
18	Organization Science	5	206	5	41,2	265	16.307	78	61,5
19	Review of Financial Studies	5	165	5	33,0	366	16.744	68	45,7
20	Accounting Review	5	151	5	30,2	255	7.684	46	30,1
21	Management Science	5	133	5	26,6	700	25.463	74	36,4
22	Strategic Entrepreneurship Journal	5	92	5	18,4	56	1.792	25	32,0
23	International Journal of Technology Management	13	69	4	5,3	439	2.127	19	4,8
24	Journal of Small Business Management	5	47	4	9,4	145	3.075	33	21,2
25	Administrative Science Quarterly	4	227	4	56,8	89	7.371	49	82,8
26	Journal of International Business Studies	4	139	4	34,8	313	15.442	66	49,3
27	Financial Management	4	57	4	14,3	132	1.590	17	12,0
28	Management Decision	6	21	3	3,5	276	2.228	21	8,1
29	Research Technology Management	5	14	3	2,8	175	1.080	15	6,2
30	R D Management	4	53	3	13,3	175	4.173	34	23,8
31	Advances In Strategic Management A Research Annual	4	26	3	6,5	88	428	10	4,9
32	Health Affairs	4	21	3	5,3	1431	29.033	76	20,3
33	Journal of Economics Management Strategy	3	58	3	19,3	180	2.871	26	16,0
34	European Financial Management	3	47	3	15,7	162	2.092	22	12,9
35	Journal of Business Research	4	51	2	12,8	789	17.616	59	22,3
36	Harvard Business Review	3	86	2	28,7	1072	9.235	45	8,6
37	Industrial and Corporate Change	3	61	2	20,3	200	4.479	34	22,4
38	Long Range Planning	3	12	2	4,0	128	2.153	26	16,8
39	Journal of Management	2	119	2	59,5	214	13.710	62	64,1
40	Ieee Transactions On Engineering Management	2	31	2	15,5	227	4.068	33	17,9

Table 6. Leading journals in venture capital between 2010-2014

R	Journal	TPV	TCV	HV	C/P1	TP	TC	H	C/P2
1	Journal of Business Venturing	38	578	14	15,2	217	3.088	31	14,2
2	Small Business Economics	30	153	8	5,1	421	2.126	20	5,0
3	Strategic Management Journal	12	170	8	14,2	436	5.480	36	12,6
4	Review of Financial Studies	17	212	7	12,5	498	6.124	67	12,3
5	Entrepreneurship Theory and Practice	16	102	7	6,38	254	3.038	27	12,0
6	Research Policy	14	143	7	10,2	628	6.986	34	11,1
7	Journal of Financial Economics	10	144	6	14,4	615	7.989	39	13,0
8	International Entrepreneurship and Management Journal	13	69	5	5,31	165	1.003	18	6,1
9	Strategic Entrepreneurship Journal	12	58	5	4,83	99	710	16	7,2
10	Academy of Management Journal	10	85	5	8,5	323	6.947	45	21,5
11	Journal of Financial and Quantitative Analysis	8	87	5	10,9	284	1.699	21	6,0
12	Journal of Management Studies	8	76	5	9,5	293	4.456	32	15,2
13	Journal of International Business Studies	7	147	5	21	288	3.772	29	13,1
14	Industrial and Corporate Change	7	43	5	6,14	276	1.636	18	5,9
15	Journal of Corporate Finance	19	72	4	3,79	413	1.648	18	4,0
16	Review of Finance	9	40	4	4,44	191	813	14	4,3
17	Corporate Governance An International Review	8	39	4	4,88	156	887	12	5,7
18	Journal of Banking Finance	8	30	4	3,75	1.450	7.019	27	4,8
19	European Financial Management	7	73	4	10,4	178	614	12	3,4
20	Organization Science	7	45	4	6,43	455	6.255	37	13,7
21	Journal of Financial Intermediation	6	38	4	6,33	139	1.275	17	9,2
22	Asia Pacific Journal of Management	6	32	4	5,33	227	1.374	16	6,1
23	Journal of Finance	5	117	4	23,4	332	5.508	35	16,6
24	International Small Business Journal	9	27	3	3	200	995	13	5,0
25	Journal of Business Research	8	25	3	3,13	1.305	5.952	25	4,6
26	Journal of Economics Management Strategy	8	16	3	2	189	610	11	3,2
27	Financial Management	7	39	3	5,57	194	713	11	3,7
28	Entrepreneurship and Regional Development	6	33	3	5,5	177	973	15	5,5
29	Harvard Business Review	6	11	3	1,83	1.363	2.030	17	1,5
30	California Management Review	5	27	3	5,4	135	760	14	5,6
31	Journal of Business Finance Accounting	5	23	3	4,6	236	690	11	2,9
32	Journal of Product Innovation Management	5	20	3	4	430	2.699	22	6,3
33	Technovation	5	16	3	3,2	283	2.573	24	9,1
34	Regional Studies	4	25	3	6,25	479	2.357	19	4,9
35	R D Management	4	23	3	5,75	164	994	15	6,1
36	Journal of Technology Transfer	7	26	2	3,71	209	1.014	16	4,9
37	International Review of Financial Analysis	6	13	2	2,17	315	475	8	1,5
38	Management Science	5	30	2	6	747	5.678	28	7,6
39	Journal of Small Business Management	4	21	2	5,25	167	904	15	5,4
40	Journal of Management	3	19	2	6,33	297	6.286	41	21,2

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Mapping journals in venture capital research with VOS viewer software

A further interesting issue to consider is mapping the leading journals in order to visualize their publication and citation structure. In order to do so, this work uses VOS viewer software (Van Eck and Waltman, 2010). VOS viewer is very useful for collecting bibliographical material providing visualizations of the bibliographic connections of documents, journals, authors and universities by using a wide range of techniques including bibliographic coupling (Kessler, 1963) and co-citation (Small, 1973).

First, we studied bibliographic coupling between journals in venture capital research. Recall that bibliographic coupling (Kessler, 1963) occurs when two documents cite the same third document. Figure 2 shows the results. Note that the figure considers journals with at least X documents in venture capital and the one hundred most representative connections in the bibliographic network.

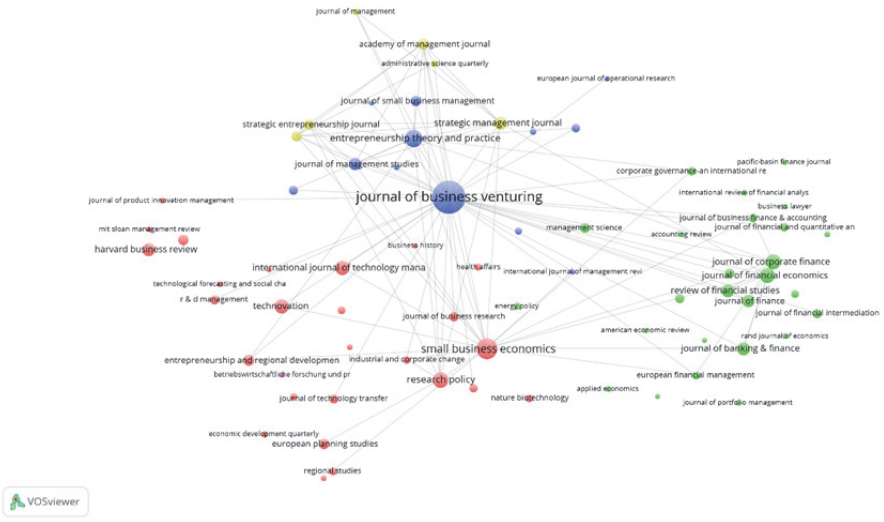

Fig.2 Bibliographic coupling of journals

The Journal of Business Venturing is at the core of the field confirming the results seen in the previous tables. It is worth noting that some leading management and financial journals also have a significant position in the field publishing a significant number of articles.

Next, let us analyze co-citation between journals in venture capital. Recall that co-citation (Small, 1973) occurs when two documents receive a citation from the same third document. Figure 3 presents the map considering a minimum threshold of X citations and the one hundred most representative connections.

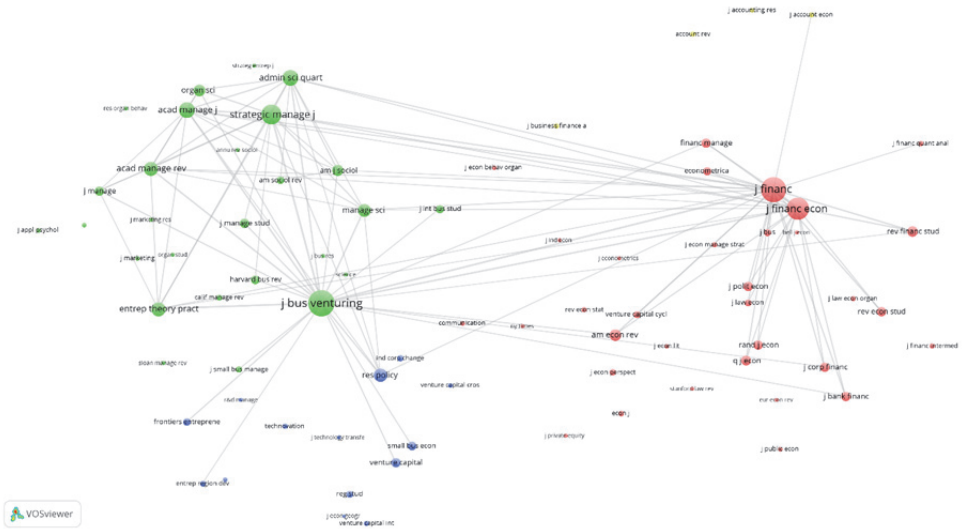

Fig.3 Co-citation of journals in venture capital

The Journal of Business Venturing is the most influential journal although the Journal of Finance and the Journal of Financial Economics also receive numerous citations. Moreover, several management journals are also very influential in the field including the Strategic Management Journal and the Academy of Management Journal.

4. Conclusions

This section presents a mathematical model which enables inventory to be reallocated. The model was presented in Oltra-Badenes (2012). The objective of the model is to optimise the allocation of inventory to orders, maximising the total sales value of the orders to be fulfilled and attempting to fulfil the orders with the earliest delivery dates.

This work presents a general overview of the leading journals in venture capital research between 1990 and 2014. Different analyses were performed, both at a general level for the described period, and also at the quinquennial level.

First, the analysis focused on studying a ranking of 40 leading journals that present a greater h-index in the discipline. In this ranking, it is possible to observe an interesting discussion that reveals that the most productive journals, i.e., those who have a greater quantity of published work, are not necessarily the most influential, i.e. those who have a greater number of citations by the scientific community. Only one case, Journal of Business Venturing which is the most productive, is also the most influential journal. Evidently, this is the only specialized journal in venture capital research. Interestingly, some cases, such as Journal of Finance, Strategic Management Journal and Journal of Banking & Finance,

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present an important number of citations (more than 1000) in fewer than 25 papers. These three journals, despite not being specialized in venture capital research, publish very influential papers. The work also develops a graphical visualization of the publication and citation structure between journals by using VOS viewer software with bibliographic coupling and co-citation.

A quinquennial analysis, five periods of five years each, allowed us to recognize the transition among journals which focuses on venture capital research. Specifically, in the first quinquennials analyzed, fewer than 15 journals published papers on venture capital, and the journals that accepted these articles come from a Finance and General Management perspective. Currently, this situation is very different. The last quinquennials analyzed show that more than 40 journals normally accept and publish papers on venture capital. This group of journals does not come from a few disciplines; in fact a wide range of perspectives that include Psychology, Law, Innovation and Sociology, among others, represents it.

Clearly, venture capital research will continue growing and it is necessary to deepen the analysis of the authors, countries and universities that lead research in this discipline, who are not only the most productive players but also the most influential actors.

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Leading universities in Latin America in business and management research

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Abstract

Latin-American universities are experiencing an important growth during the last decades. This study analyzes the most productive and influential institutions in Latin America in business and management research between 1990 and 2014. The results indicate that Brazilian and Chilean institutions are the most relevant ones in the region although some top universities from other Latin-American countries do also appear in the rankings. The results available in Web of Science indicate that Latin-American institutions are very productive in four main areas: general management journals, innovation and entrepreneurship, operations research and finance.

Keywords: *Latin America; management; university analysis; bibliometrics; Web of Science.*

Introduction

Latin America is a region that encompasses all the countries in America south of the USA and with a major influence by Spanish or Portuguese languages (Nicholls-Nixon, Dávila-Castilla, Sánchez-García, & Rivera-Pesquera, 2011). Currently, these countries are experiencing a profound change in their economies due to a major development process that is modernizing the living standards of the region (West, Bamford, & Marsden, 2008). All these countries are emerging economies that are expected to become very relevant in the near future (Grugel, Riggirozzi, & Thirkell-White, 2008). Currently, Latin America has a population close to 600 million people and an area of 20 million square kilometers. Brazil and Mexico are the biggest countries in the region accounting for more than half of the population.

Many scholars study a wide range of issues on this region in order to obtain a general perspective. A major work from the management point of view is the study by Nicholls-Nixon et al. (2011) that identifies the main factors that condition the region and suggests future directions for improvement. From the academic perspective,

business and management research in Latin America is growing a lot (Carneiro & Brenes, 2014; Rivera-Camino & Gómez-Mejia, 2006). Every year, more people gets access to higher education and many institutions are appearing in order to cover the growing demand. This implies the need for more professors and more business and management departments. Over the last years, the number of professors in Latin America has grown exponentially in almost all the fields. In business and management, it is very common that the highest quality professors obtain their highest degrees in North America or Europe before establishing in the region. Thus, their knowledge follows the standards of the developed nations which are an important issue for success in the future. However, from a general point of view, the current number of publications in Latin America is very low compared to the number of publications of developed countries, especially in the high-quality journals (Olavarrieta & Villena, 2014). There is a lot of growth in order to solve this weakness, for example, with the creation and consolidation of journals in the region including Academia – Latin American Journal of Administration, Innovar – Journal of Administrative and Social Sciences, and the Latin American Business Review.

The aim of this study is to analyze the leading universities in Latin America in business and management research by using a bibliometric approach. Currently, there are many rankings that evaluate business schools in Latin America according to a wide range of teaching indicators. But there is no study that considers the research perspective from a strict point of view and focusing on universities and business schools. For developing the analysis, we study many indicators including the total number of publications and citations of an institution and a distinction between the Top 102 and all the journals. The results indicate that the leading universities are established in Chile, Brazil and Mexico although some important universities are also located in other countries. Since business and management is a very broad discipline, the work also considers different categories following a CNRS report that we will describe in the methodology section. In general, innovation and entrepreneurship, operations research, general management and finance are the most popular topics in this region according to the number of articles published in the Web of Science (WoS) journals.

This paper is organized as follows. The second section briefly reviews the previous literature in this field. The third section analyzes the bibliometric methods used in the study. The fourth section presents the results which include a global university ranking, a temporal analysis, a bibliographic coupling and a co-authorship perspective, and a ranking by categories. The fifth section discusses the main findings and conclusions of the article.

1. Literature review

There are many works that study business and management in Latin America under a wide range of perspectives. Nicholls-Nixon et al. (2011) presents a general overview considering the most influential and updated issues in the region from a management point of view. Geyikdagi & Geyikdagi (1989) study the international diversification in Latin America and compare it with the developed nations. Grosse (1981) considers the subsidiaries of the multinational enterprises in Latin America. Lenartowicz & Johnson (2003) compare the managerial values available in different countries of the region and Dávila & Elvira (2012) the humanistic leadership in Latin America. Cuervo-Cazurra (2008) analyzes the multi-nationalization of Latin-American enterprises and Treviño & Mixon (2004) foreign direct investment in the region. Vassolo, De Castro, & Gómez-Mejía (2011) study general issues and establish a research agenda. Newburry, Gardberg, & Sánchez (2014) focus on the employer attractiveness through the association of foreignness, internationalization and talent recruitment and Posthuma, Levashina, & Lievens (2014) compare employment interviews. Sepulveda and Bonilla (2014) analyze the factors affecting the risk attitude in entrepreneurship. Brenes, Montoya, & Ciravegna (2014) analyze differentiation strategies and Khoury, Junkunc, & Mingo (2015) venture capital investments in Latin America. Some other authors focus on one specific country including Del Sol & Kogan (2007) and Amorós, Felzenstein, & Gimmon (2013) in Chile, Kotabe, Parente, & Murray (2007) and Lopes-Santos, Cruz-Basso, Kimura, & Kayo (2014) in Brazil, Muller & Kolk (2009) in Mexico, and Sully de Luque & Arbaiza (2005) in Peru. Additionally, several journals publish special issues focused exclusively in business and management issues in Latin America including the Journal of Business Research (Raventos & Ospina, 2013; Sanz & Jones, 2013), Management Decision (Robles, 2013), and the Journal of Organizational Change Management (Ribeiro-Soriano, 2012).

There are also few studies that analyze business and management research in Latin America from an academic perspective. Koljatic & Silva (2001) provide a general overview considering both business and economics. They find that only four countries have a significant research production: Argentina, Brazil, Chile, and Mexico. Cardoza & Fornés (2011) and Ronda-Pupo, Díaz-Contreras, Ronda-Velázquez, & Ronda-Pupo (2015) study the academic collaboration between Latin-American and Ibero-American countries. Some other works focus on a specific Latin-American country such as the case of Brazil (Rodríguez-Pereira, Fisher, & Loureiro-Escuder, 2000). However, none of these studies focuses on universities in order to identify the leading places on business and management research in the region. Therefore, currently there is an open question in order to identify the leading institutions in Latin America. Our article will try to address this issue by using a bibliometric methodology.

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Bibliometrics is the research field that studies quantitatively the bibliographic material (Broadus, 1987). It is very useful for providing a general overview of a research field by using a wide range of indicators. Bibliometric studies are becoming very popular in the literature, especially because of the development of computers and internet that facilitates a lot the acquisition of information. This concept is close to other related ones in library and information sciences including scientometrics and informetrics (Bar-Illan, 2008). In the literature there are many bibliometric analysis in a wide range of areas including economics (Coupé, 2003), entrepreneurship (Landström, Harirchi, & Aström, 2012), social entrepreneurship (Rey-Martí, Ribeiro-Soriano, & Palacios-Marqués, 2016), innovation (Fagerberg, Fosaas, & Sapprasert, 2012; Merigó, Cancino, & Coronado, 2016), business incubators (Albort-Morant & Ribeiro-Soriano, 2016), international business (Treviño, Mixon, Funk, & Inkpen, 2010) and health economics (Wagstaff & Culyer, 2012).

In management, Podsakoff, MacKenzie, Podsakoff, & Bachrach (2008) present a general overview of the most influential authors and institutions. The results indicate that the USA and the English-speaking countries have a very strong position in the field because almost all the authors and institutions are from this region although some authors may work in these countries but having a different nationality. Some other works provides similar results although focusing in some other related concepts including the work of Aguinis, Suárez-González, Lannelongue, & Joo (2012) that analyze authors and Stahl, Leap, & Wei (1988) that study institutions. All these articles first defined a set of leading management journals in order to generate the rankings.

Journal ranking are very common in the business and management literature. Johnson & Podsakoff (1994) present a ranking based on an index developed by Salancik (1986). Geary, Marriot, & Rowlinson (2004) uses a UK perspective for ranking the journals based on the 2001 research assessment exercise that classifies the journals in different tiers. Podsakoff, MacKenzie, Bachrach, & Podsakoff (2005) analyze the in influence of business and management in the eighties and nineties. Mingers, Macri, & Petrovici (2012) present the quality of management journals by using the modern h-index (Hirsch, 2005). Peters, Daniels, Hodgkinson, & Haslam (2014) develop a ranking based on the opinion of experts. Most of the studies obtain similar rankings because the leading journals are usually the same although their positions may change a bit depending on the criteria used.

Some other articles focus on a specific journal, often motivated by a remarkable anniversary or event of the journal. Colquitt & Zapata (2007) analyzed the Academy of Management Journal after the 50th anniversary and Clark, Wright, Iskoujina, & Garnett (2014), the Journal of Management Studies. Van Fleet et al. (2006) focus on the Journal of Management for the 30th anniversary and Bauer (2009), for the 35th

anniversary. Ramos and Rodríguez (2004) analyze the Strategic Management Journal between 1980 and 2000. Knight, Hult, & Bashaw (2000) focus on the Journal of Business Research between 1985 and 1999, and Merigó, Mas-Tur, Roig-Tierno, & Ribeiro-Soriano (2015) between 1973 and 2014. The main advantage of using bibliometric studies in one specific journal is the possibility of obtaining a complete overview of the leading trends that are affecting the journal under a wide range of perspectives including authors, institutions, topics and countries.

Additionally, there are some works that analyze the management research of a specific country or region. Danell (2000) studies the network generated between European and American journals. Erkut (2002) analyzes management research in Canada and founds relatively low results compared to the expectations for Canada. Bruton & Lau (2008) develop a similar analysis for the Asian school and Doyle & Arthurs (1995) and Geary et al. (2004) for the UK. Vogel (2012) studies colleges of management and organization studies by using a bibliometric approach.

2. Methods

Business and management is a very broad discipline that encompasses many subfields. Therefore, an important issue in order to study this area is to classify it in different topics. For doing so, this article follows the methodology developed by the Section 37 of Economics and Management of the Comité National de la Reserche Scientifique (CNRS) of France for categorizing academic journals indicating their quality. There are several editions of the journal report. This study mainly uses the version 3.01 (October 2011) because it is the current version used by the Chilean National Science Foundation (CONICYT) which is available at:
https://www.gate.cnrs.fr/spip.php?rubrique31&lang=en. However, in some cases, we use the latest version in order to consider the newest updates to the list. According to this, this work divides business and management in thirteen categories which are presented in Table 1.

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Table 1. Thirteen business and management categories according to the CNRS report

Abbreviation	Category
ACC	Accounting
BSIM	Business Strategy & International Management
FIN	Finance
GM	General Management
HRM	Human Resource Management
IE	Innovation & Entrepreneurship
MIS	Management Information Systems
MKT	Marketing
OBM	Other Business and Management Activities
OR	Operations Research
OS	Organization Studies
POM	Production & Operations Management
SPJ	Spanish and Portuguese Journals

Source: Own

Currently, Latin American institutions do not publish many papers in the leading journals (Bonilla, Merigó, & Torres-Abad, 2015). Therefore, it is not possible to develop comprehensive rankings by only considering these Top 10 or 30 journals as it is used in World rankings (Podsakoff et al. 2008). In order to solve this problem, this study uses a larger group of journals. Particularly, we select all the journals that receive an evaluation of 1 or 2 in the CNRS report in the business and management categories. Moreover, we only consider those journals that are available in the WoS categories of Business, Business Finance, and Management. Currently, there are 349 journals in these categories and are available at the Thomson and Reuters webpage: http://ip-science.thomsonreuters.com/cgi-bin/jrnlst/jlsubcatg.cgi?PC=SS. Note that 329 journals are included in the Journal Citation Reports (JCR) of WoS. Of all these journals, 102 reach the high-quality evaluation of 1 or 2 in the CNRS report. Additionally, the work also considers the total number of publications in the most selective journals which are grouped in a Top 8 and Top 41 selection as it is shown in Table 2 together with the rest of Top 102 journals.

Table 2. List of Top 102 business and management journals

Journal name	IF	5Y-IF	Category
Top 8			
Academy of Management Review	7,817	9,698	GM
Accounting Review	2,234	3,426	ACC
Administrative Science Quarterly	2,394	7,057	GM
Journal of Finance	6,033	7,399	FIN
Journal of Marketing	3,819	6,682	MK
Management Science	2,524	3,458	OR
MIS Quarterly	5,405	8,157	MIS
Strategic Management Journal	2,993	5,929	BSIM
Next Top 33 Journals			
Academy of Management Journal	4,974	8,443	GM
Accounting, Organizations and Society	2,109	3,834	ACC
Entrepreneurship: Theory and Practice	2,447	3,810	IE
European Journal of Operational Research	1,843	2,625	OR
Information Systems Research	2,322	4,276	MIS
Journal of Accounting & Economics	2,833	4,668	ACC
Journal of Accounting Research	2,449	3,774	ACC
Journal of Applied Psychology	4,367	6,952	OS
Journal of Business Venturing	3,265	4,571	IE
Journal of Consumer Psychology	1,708	2,021	MK
Journal of Consumer Research	2,783	4,776	MK
Journal of Economics & Management Strategy	1,042	1,781	BSIM
Journal of Environmental Economics and Management	2,522	3,398	OBM
Journal of Financial and Quantitative Analysis	1,877	2,782	FIN
Journal of Financial Economics	3,769	5,719	FIN
Journal of International Business Studies	3,594	5,534	BSIM
Journal of Management	6,862	8,027	GM
Journal of Management Information Systems	1,925	3,305	MIS
Journal of Management Studies	3,277	5,196	GM
Journal of Marketing Research	2,660	3,796	MK
Journal of Operations Management	4,478	7,718	POM
Journal of Product Innovation Management	1,379	2,770	IE
Marketing Science	2,208	3,012	MK
Operations Research	1,500	2,498	OR
Organization	2,354	2,655	OS
Organization Science	3,807	5,512	OS
Organization Studies	2,504	3,355	OS
Organizational Behavior and Human Decision Processes	2,897	3,935	OS
Personnel Psychology	4,540	5,845	HRM
Research Policy	2,598	3,989	IE
Review of Accounting Studies	1,167	1,935	ACC
Review of Finance	1,636	2,533	FIN
Review of Financial Studies	3,532	6,257	FIN
Next Top 61 Journals			
Academy of Management Annals	7,333	10,154	GM
Academy of Management Learning & Education	2,121	3,579	GM
Academy of Management Perspectives	2,826	3,766	GM
Advances in Strategic Management	0,517	0,551	BSIM
Auditing: A Journal of Practice & Theory	1,449	1,946	ACC
British Journal of Management	1,909	2,661	GM
California Management Review	1,944	2,672	GM
Contemporary Accounting Research	1,533	2,296	ACC
Decision Sciences	1,561	3,025	OR
European Accounting Review	0,942	1,519	ACC
European Management Review	0,900	1,701	GM

Family Business Review	4,243	3,592	IE
Financial Management	0,873	1,656	FIN
Geneva Risk and Insurance Review	0,381	0,364	FIN
Harvard Business Review	1,831	2,070	GM
Human Relations	1,867	2,952	HRM
Human Resource Management	1,395	2,517	HRM
IEEE Transactions on Engineering Management	0,938	1,557	POM
Industrial and Corporate Change	1,330	2,071	OS
Industrial Marketing Management	1,897	2,366	MK
Information & Management	1,788	3,392	MIS
Information and Organization	2,538	2,508	MIS
International Journal of Electronic Commerce	2,150	2,350	MIS
International Journal of Management Reviews	2,673	4,468	GM
International J. Operations & Production Management	1,518	2,472	POM
International Journal of Research in Marketing	1,710	2,555	MK
International Small Business Journal	1,397	1,938	IE
Journal of Accounting and Public Policy	1,115	1,444	ACC
Journal of Banking & Finance	1,362	1,948	FIN
Journal of Business	-	-	GM
Journal of Business Ethics	1,552	1,889	OBM
Journal of Business Finance & Accounting	1,261	1,240	ACC
Journal of Business Logistics	2,886	3,713	POM
Journal of Business Research	1,306	2,341	GM
Journal of Corporate Finance	1,400	1,802	FIN
Journal of Financial Intermediation	1,625	2,534	FIN
Journal of Occupational and Organizational Psychology	2,480	3,052	OS
Journal of Organizational Behavior	3,262	4,734	OS
Journal of Retailing	1,193	2,452	MK
Journal of Risk and Insurance	1,000	1,408	FIN
Journal of Risk and Uncertainty	1,396	2,185	FIN
Journal of Service Research	2,143	4,109	OBM
Journal of Small Business Management	1,361	2,298	IE
Journal of Strategic Information Systems	2,571	3,130	MIS
Journal of the Academy of Marketing Science	3,410	4,518	MK
Journal of the Operational Research Society	0,911	1,272	OR
Journal of World Business	1,907	3,039	BSIM
Leadership Quarterly	2,006	3,006	OS
Long Range Planning	2,111	4,365	POM
Management Accounting Research	1,421	2,378	ACC
Marketing Letters	0,642	1,201	MK
Mathematical Finance	1,348	1,599	FIN
MIT Sloan Management Review	1,803	1,988	GM
Omega – International Journal of Management Science	3,190	3,626	OR
Organizational Dynamics	0,446	0,929	OS
Organizational Research Methods	3,525	5,713	OS
Research in Organizational Behavior	1,250	4,870	OS
Review of Industrial Organization	0,468	0,667	OS
Small Business Economics	1,641	2,621	IE
Strategic Entrepreneurship Journal	1,744	2,724	IE
Technological Forecasting and Social Change	1,959	2,405	IE

The Web of Science is the database that we use in order to collect the information. Currently, it includes more than 50.000.000 articles and it is classified in about 250 categories and 150 research areas. The information was collected between March and April of 2015. The search process is developed by searching for articles with Latin-

American affiliation in the Top 102 journals and at a second level in all the Business, Business Finance, and Management journals available in WoS. The study considers a time period of twenty-five years from 1990 until 2014. During this period, Latin-American institutions have published 1335 articles in the Top 102 journals and 3656 in all the Business, Business Finance, and Management journals available in WoS. With these articles, this work develops the bibliometric approach in order to identify the leading institutions in the region.

This article considers many bibliometric indicators in the analysis. The main advantage of doing so is that the available information is represented in a more complete way because many perspectives can be considered according to the specific interests of the reader (Merigó, Gil-Lafuente, & Yager, 2015). Among others, this study considers the well-known number of publications and citations and the h-index (Hirsch, 2005). Note that the h-index combines articles and citations in the same indicator. That is, if a set of publications have an h-index of 15, inside the set, there are 15 articles that have received 15 citations or more but there are not 16 studies or more with at least 16 citations. Note that in the literature there are a lot of studies discussing about which should be the optimal measure for evaluating research. In general, the main conclusion is that it depends on the specific topic or issue because each measure has different characteristics. In management, Podsakoff et al. (2008) argues that citation analysis is the optimal way for evaluating research because it measures the influence of a set of articles written by an author or a university. However, there are other studies that focus on the number of publications because it measures the author or university productivity (Trieschmann, Dennis, Northcraft, & Niemi, 2000).

3. Results

This Section presents the results of the study which are divided in three parts. The first part presents the leading institution in business and management in Latin America. The second part analyzes the leading institutions in different categories and the third one a temporal evolution.

3.1. Leading institutions in business and management in Latin America

Over the last twenty-five years, Latin-American research institutions are experiencing a strong expansion with a huge increase in the number of publications in international journals. Table 3 presents the top 50 universities (e.g. leading institutions) ranked by h-index, which is calculated by considering the top 102 journals introduced in Table 2. Table 3 also include, as a second level of analysis, the same index by considering all journals available in WoS in Business, Business Finance, and Management categories.

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Table 3. Global ranking of Latin American institutions in business and management research

			Top 102 Journals						All Journals			
R	**University**	**Cou**	**TP**	**TC**	**H**	**C/P**	**T8**	**T41**	**TP**	**TC**	**H**	**C/P**
1	U Chile	CHL	81	1425	22	17,59	7	46	209	1967	25	9,41
2	U Sao Paulo	BRA	101	1417	18	14,03	2	43	293	1822	20	6,22
3	Catholic U Chile	CHL	92	1171	18	12,73	6	43	135	1361	20	10,08
4	Federal U Rio de Janeiro	BRA	62	1101	17	17,76	1	31	136	1228	17	9,03
5	Tec Monterrey	MEX	56	1051	17	18,77	1	20	118	1323	19	11,21
6	U Estadual Campinas	BRA	51	741	16	14,53	0	35	92	856	16	9,30
7	ITAM Mexico	MEX	29	527	12	18,17	6	16	72	897	15	12,46
8	Federal U Rio Grande do Sul	BRA	30	515	11	17,17	0	14	68	580	12	8,53
9	Federal U Minas Gerais	BRA	30	406	11	13,53	1	21	81	496	12	6,12
10	Adolfo Ibañez U	CHL	42	725	10	17,26	5	16	74	811	10	10,96
11	Federal U Sao Carlos	BRA	19	268	10	14,11	0	10	43	301	10	7,00
12	Austral U	ARG	20	415	9	20,75	3	10	23	430	9	18,70
13	Federal U Fluminense	BRA	24	232	8	9,67	0	23	48	338	10	7,04
14	U Andes Colombia	COL	40	229	8	5,73	0	14	94	314	9	3,34
15	Federal U Pernambuco	BRA	14	176	8	12,57	0	8	50	275	10	5,50
16	INCAE Business School	C.R	50	213	7	4,26	0	0	60	207	7	3,45
17	Catholic U Rio de Janeiro	BRA	31	206	7	6,65	1	12	57	413	11	7,25
18	U Central Venezuela	VEN	13	100	7	7,69	0	11	26	102	7	3,92
19	U Brazilia	BRA	15	385	6	25,67	0	5	48	481	9	10,02
20	Federal U Santa Catarina	BRA	13	152	6	11,69	0	10	51	190	7	3,73
21	Aut U Sinaloa	MEX	7	125	6	17,86	0	7	7	125	6	17,86
22	IBMEC Sao Paulo	BRA	7	141	5	20,14	1	6	9	156	6	17,33
23	Metro Aut U Mexico	MER	13	99	5	7,62	1	8	28	165	7	5,89
24	U Republic Uruguay	URU	10	98	5	9,80	0	5	29	213	7	7,34
25	U Americas Puebla	MEX	9	89	5	9,89	1	6	19	186	8	9,79
26	Simón Bolivar U	VEN	15	88	5	5,87	0	14	25	89	5	3,56
27	U Estadual Paulista	BRA	13	87	5	6,69	0	9	28	120	6	4,29
28	U Buenos Aires	ARG	11	75	5	6,82	0	7	48	136	6	2,83
29	IPN Mexico	MEX	8	73	5	9,13	0	0	12	91	5	7,58
30	Catholic U Peru	PER	12	69	5	5,75	0	1	46	180	8	3,91
31	U Concepción	CHL	6	62	5	10,33	0	4	14	70	5	5,00
32	National U Colombia	COL	7	51	5	7,29	0	4	18	153	6	8,50
33	Catholic U Brazilia	BRA	10	66	4	6,60	0	3	23	481	9	20,91
34	U San Andrés	ARG	7	63	4	9,00	1	4	15	83	5	5,53
35	U Andes Chile	CHL	6	53	4	8,83	0	2	11	75	5	6,82
36	Federal U Paraiba	BRA	6	49	4	8,17	0	3	14	57	4	4,07
37	U Bio Bio	CHL	4	48	4	12,00	0	1	7	49	4	7,00

38	IESA	VEN	7	34	4	4,86	0	0	19	48	5	2,53
39	U Valle	COL	4	563	3	140,75	0	4	13	601	5	46,23
40	U Francisco Marroquin	GUA	3	140	3	46,67	0	3	4	140	3	35,00
41	Benem U Aut Puebla	MEX	4	95	3	23,75	0	4	8	96	3	12,00
42	U Diego Portales	CHL	5	52	3	10,40	0	1	18	56	3	3,11
43	Federal U Espiritu Santo	BRA	4	44	3	11,00	0	4	10	48	3	4,80
44	U Santiago de Chile	CHL	3	42	3	14,00	0	2	18	54	4	3,00
45	Aut U Nueva León	MEX	10	34	3	3,40	0	7	16	36	3	2,25
46	UNAM	MEX	10	34	3	3,40	0	4	37	227	9	6,14
47	Catholic U Parana	BRA	3	37	3	12,33	0	0	21	60	5	2,86
48	U Talca	CHL	8	31	3	3,88	0	7	19	113	6	5,95
49	U Presbiter Mackenzie	BRA	6	33	3	5,50	0	2	20	33	3	1,65
50	U Desarrollo	CHL	6	29	3	4,83	0	0	16	49	3	3,06

Abbreviations: R = Rank; Cou = Country; TP and TC = Total number of publications and citations; C/P = Citations divided by publications; H = H-index; T8 and T41 = Number of publications in the Top 8 and Top 41 journals.

The University of Chile obtains the best results although the University of Sao Paulo publishes more articles in the Top 102 and all WoS journals in Business, Business Finance and Management. However, the University of Chile publishes more studies in the high-quality journals of the Top 8 and Top 41. The Catholic University of Chile appears in the third position and very close to the previous two. In general, Brazil is the country with the highest number of institutions in the ranking with nineteen universities. Chile gets the second position tied with Mexico with nine universities which is very remarkable considering that it is ten times smaller than Brazil. The rest of the countries are less influential. Argentina, Colombia and Venezuela have 3 institutions each in the ranking. Costa Rica, Uruguay, Peru and Guatemala have one institution each in the list. The rest of Latin-American countries do not have any university in the Top 50.

Another interesting issue is to consider the collaboration network of Latin-American institutions with foreign ones. For doing so, Table 4 presents the Top 50 institutions with the highest degree of collaboration (measured by the h-index) according to the Top 102 journals.

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Table 4. Leading foreign universities co-autoring with Latin American

			Top 102 Journals						All Journals			
R	**University**	**Cou**	**TP**	**TC**	**H**	**C/P**	**T8**	**T41**	**TP**	**TC**	**H**	**C/P**
1	MIT	USA	19	994	14	52,32	4	15	36	1061	16	29,47
2	U Montreal	CAN	26	440	11	16,92	0	18	34	451	11	13,26
3	U North Carolina	USA	10	605	8	60,50	1	7	18	642	9	35,67
4	IE University	SPA	9	489	8	54,33	0	0	18	494	8	27,44
5	Ohio State U	USA	10	144	8	14,40	0	4	11	145	8	13,18
6	Georgia Inst Techn	USA	10	639	7	63,90	0	8	14	642	7	45,86
7	U London	UK	14	254	7	18,14	0	5	31	359	10	11,58
8	U California Berkeley	USA	11	253	7	23,00	1	4	11	253	7	23,00
9	Arizona State U	USA	10	235	7	23,50	1	6	12	252	7	21,00
10	Harvard U	USA	16	213	7	13,31	3	7	22	231	7	10,50
11	U Minnesota Twin Cities	USA	8	541	6	67,63	0	3	15	1202	7	80,13
12	U Texas Arlington	USA	6	246	6	41,00	0	3	6	249	6	41,50
13	U Georgia	USA	6	184	6	30,67	0	2	8	191	7	23,88
14	U Warwick	UK	8	168	6	21,00	0	3	17	204	7	12,00
15	Columbia U	USA	12	150	6	12,50	4	11	16	150	6	9,38
16	U Valencia	SPA	9	87	6	9,67	0	4	27	117	6	4,33
17	U Pennsylvania	USA	11	315	5	28,64	0	7	11	316	5	28,73
18	John Hopkins U	USA	7	190	5	27,14	0	5	9	191	5	21,22
19	U Oklahoma	USA	6	148	5	24,67	0	3	7	153	5	21,86
20	Florida State U	USA	5	142	5	28,40	0	0	5	142	5	28,40
21	U Arizona	USA	6	141	5	23,50	0	5	7	142	5	20,29
22	U Texas Austin	USA	8	139	5	17,38	0	5	16	207	6	12,94
23	U Liverpool	UK	7	108	5	15,43	0	4	8	112	5	14,00
24	Lingnan U	CHN	6	89	5	14,83	0	3	6	91	5	15,17
25	Georgia State U	USA	7	78	5	11,14	0	0	8	88	6	11,00
26	U Southern California	USA	8	77	5	9,63	0	5	12	123	7	10,25
27	Texas A&M U College	USA	7	53	5	7,57	2	4	9	65	5	7,22
28	U Michigan	USA	6	241	4	40,17	1	3	8	264	5	33,00
29	U Colorado Boulder	USA	5	191	4	38,20	0	5	7	206	5	29,43
30	McGill U	CAN	5	185	4	37,00	0	4	6	199	5	33,17
31	U Toronto	CAN	6	184	4	30,67	0	3	9	197	5	21,89
32	Georgetown U	USA	4	157	4	39,25	0	2	6	186	5	31,00
33	U Amsterdam	NET	6	146	4	24,33	0	3	8	178	5	22,25
34	Florida International U	USA	7	113	4	16,14	0	2	13	125	4	9,62
35	U Manchester	UK	7	96	4	13,71	0	1	18	154	6	8,56
36	Erasmus U Rotterdam	NET	11	83	4	7,55	0	7	19	161	6	8,47
37	Simon Fraser U	CAN	6	76	4	12,67	0	1	11	109	4	9,91
38	National U Singapore	SGP	7	75	4	10,71	0	3	8	84	5	10,50
39	Carnegie Mellon U	USA	6	73	4	12,17	1	5	8	130	6	16,25
40	Bentley U	USA	4	71	4	17,75	0	0	4	71	4	17,75
41	U Queensland	AUS	6	70	4	11,67	0	2	9	72	4	8,00
42	Penn State U	USA	8	59	4	7,38	0	2	12	71	4	5,92
43	U Massachusetts Amherst	USA	4	33	4	8,25	0	2	7	37	4	5,29
44	U Carlos III Madrid	SPA	6	23	4	3,83	0	1	18	53	5	2,94
45	Southern Illinois U	USA	4	395	3	98,75	1	1	6	400	4	66,67
46	Duke U	USA	5	238	3	47,60	1	3	7	251	3	35,86
47	Chinese U Hong Kong	CHN	8	144	3	18,00	0	4	10	157	4	15,70
48	Complutense U Madrid	SPA	6	131	3	21,83	0	2	20	144	3	7,20
49	Pompeu Fabra U	SPA	4	83	3	20,75	0	3	11	102	4	9,27
50	U Lisboa	POR	5	82	3	16,40	1	3	9	87	3	9,67

The Massachusetts Institute of Technology (MIT) is the institution with the highest degree of collaboration with Latin-American universities according to the number of studies co-authored in the Top 102 journals. The University of Montreal also obtains remarkable results. In general, the USA is the country with the highest degree of collaboration with Latin America with thirty universities in the list. Spain appears in the second position with five institutions which is very remarkable considering that it is much smaller than the USA and has a lower publication record. The UK and Canada have four universities each in the list and Netherlands and China have two. Singapore, Australia and Portugal have one institution each.

3.2. Leading institutions in different business and management categories

Business and management is a very broad discipline that often encompasses several departments in universities and business schools. In order to provide a deeper analysis of the results presented in Table 3, this section classifies the publications by following the categories presented in Table 1. Note that the journals included in each category are those available in WoS categories of Business, Business Finance and Management and following the methodology of the CNRS report mentioned in Section 3. Table 5 presents the leading institutions in the categories of General Management (GM) and Other Business and Management Activities (OBM).

Table 5 Leading institutions in GM and OBM

	General Management					Other Business and Management Activities				
R	**Institution**	**TP**	**TC**	**H**	**C/P**	**Institution**	**TP**	**TC**	**H**	**C/P**
1	INCAE Business School	47	154	7	3,28	Tec Monterrey	28	154	8	5,50
2	Catholic U Chile	21	201	7	9,57	U Sao Paulo	20	87	5	4,35
3	ITAM Mexico	8	141	6	17,63	U Brasilia	8	131	4	16,38
4	Catholic U Peru	17	84	6	4,94	U Andes Colombia	18	34	3	1,89
5	U Chile	18	257	5	14,28	Catholic U Peru	8	22	3	2,75
6	Tec Monterrey	8	140	5	17,50	U Adolfo Ibañez	5	21	3	4,20
7	Adolfo Ibañez U	12	127	4	10,58	Federal U Rio de Janeiro	12	17	3	1,42
8	Austral U	5	66	4	13,20	Catholic U Chile	3	105	2	35,00
9	U Andes Colombia	22	43	4	1,95	U Chile	4	50	2	12,50
10	IESA	6	30	3	5,00	Col Mexico	4	26	2	6,50
11	U Diego Portales	3	31	2	10,33	U Concepción	2	22	2	11,00
12	Universidad de Bio Bio	3	25	2	8,33	Catholic U Brasilia	2	18	2	9,00
13	IPN Mexico	2	8	2	4,00	U Met Piracicaba	2	16	2	8,00
14	Metro Aut U Mexico	2	17	1	8,50	Federal U Santa Catarina	2	14	2	7,00
15	IPADE Business School	3	11	1	3,67	Federal U Sao Carlos	3	13	2	4,33
16	Pan U City Mexico	3	11	1	3,67	Federal U Minas Gerais	2	4	2	2,00
17	U North - Chile	2	7	1	3,50	Tec Inst Santo Domingo	1	28	1	28,00
18	U Santiago Chile	2	5	1	2,50	U The West Indies	8	27	1	3,38
19	U Buenos Aires	2	5	1	2,50	Instituto Tecnológico Celaya	3	20	1	6,67
20	U Belgrano	1	5	1	5,00	FGV Brazil	1	14	1	14,00

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The Catholic University of Chile obtains the first position but with very similar results than the INCAE Business School. It is worth noting than none of the Brazilian institutions reaches the Top 20 in GM. However, nine of the universities in the OBM list are from Brazil.

Next, let us look into the leading institutions in Innovation and Entrepreneurship (IE) and Production and Operations Management (POM). Table 6 shows the results.

Table 6 Leading institutions in IE and POM

	Innovation & Entrepreneurship					Production & Operations Management				
R	**Institution**	**TP**	**TC**	**H**	**C/P**	**Institution**	**TP**	**TC**	**H**	**C/P**
1	U Estadual Campinas	25	155	8	6,20	Tec Monterrey	11	239	7	21,73
2	Federal U Rio de Janeiro	17	415	6	24,41	U Sao Paulo	19	93	6	4,89
3	UNAM Mexico	12	121	6	10,08	Federal U Rio Grande do Sul	6	90	4	15,00
4	U Sao Paulo	21	122	5	5,81	Federal U Rio de Janeiro	9	39	4	4,33
5	U Buenos Aires	7	48	5	6,86	Federal U Pernambuco	7	44	3	6,29
6	ITAM Mexico	5	108	4	21,60	Catholic U Chile	5	36	3	7,20
7	Federal U Minas Gerais	10	73	4	7,30	Austral U Chile	2	79	2	39,50
8	FGV Brazil	4	48	4	12,00	U Talca	2	53	2	26,50
9	U Republic Uruguay	4	51	3	12,75	Federal U Minas Gerais	3	49	2	16,33
10	U Chile	5	45	3	9,00	U Chile	3	16	2	5,33
11	U Desarrollo	7	41	3	5,86	U Magallanes	1	64	1	64,00
12	Metro Aut U Mexico	11	38	3	3,45	Austral U	1	28	1	28,00
13	Tec Monterrey	8	35	3	4,38	U Valle	2	20	1	10,00
14	Adolfo Ibañez U	4	20	3	5,00	U Estadual Paulista	2	19	1	9,50
15	Federal U Bahia	3	16	3	5,33	U San Andres	1	13	1	13,00
16	Catholic U Chile	4	51	2	12,75	Catholic U Rio de Janeiro	1	12	1	12,00
17	U San Andres	2	24	2	12,00	U La Sabana	1	11	1	11,00
18	U Estadual Paulista	5	13	2	2,60	Adolfo Ibañez U	1	11	1	11,00
19	State U Rio de Janeiro	2	11	2	5,50	IBMEC Sao Paulo	1	8	1	8,00
20	Catholic U Peru	4	10	2	2,50	U Santo Tomas	1	8	1	8,00

Brazil is the leading country in IE and POM with eight institutions in the Top 20. Chile and Mexico have four institutions each in the IE list. Chile also obtains remarkable results in POM with seven institutions.

Now, let us analyze the top universities in Marketing (MK) and Business Strategy and International Management (BSIM). Table 7 presents the results found in WoS.

Table 7 Leading institutions in MK and BSIM

	Marketing					Business Strategy & International Management				
R	**Institution**	**TP**	**TC**	**H**	**C/P**	**Institution**	**TP**	**TC**	**H**	**C/P**
1	Adolfo Ibañez U	10	66	5	6,60	Tec Monterrey	10	337	6	33,70
2	U Chile	10	174	4	17,40	ITAM Mexico	6	206	5	34,33
3	Federal U Rio Grande do Sul	6	100	4	16,67	Austral U	6	149	4	24,83
4	Tec Monterrey	8	47	4	5,88	Adolfo Ibañez U	3	357	3	119,00
5	ITAM Mexico	4	49	3	12,25	U Sao Paulo	9	62	3	6,89
6	Catholic U Chile	5	41	3	8,20	Catholic U Chile	5	40	3	8,00
7	Federal U Parana	3	27	3	9,00	U Francisco Marroquin	2	127	2	63,50
8	U Sao Paulo	9	237	2	26,33	U Andes Chile	2	5	2	2,50
9	U Brasilia	3	235	2	78,33	INCAE Business School	1	48	1	48,00
10	U Vale Rio Dos Sinos Unisonos	3	41	2	13,67	IBMEC Sao Paulo	1	27	1	27,00
11	Federal U Minas Gerais	2	27	2	13,50	U Santiago Chile	1	26	1	26,00
12	Catholic U Peru	3	13	2	4,33	Tec Inst Celaya	1	21	1	21,00
13	Catholic U Rio Grande do Sul	3	13	2	4,33	U Fortaleza	1	21	1	21,00
14	EGADE	2	9	2	4,50	U Andes Colombia	1	21	1	21,00
15	Federal U Rio de Janeiro	2	8	2	4,00	U Holguín Oscar Lucero Moya	1	16	1	16,00
16	Catholic U Rio de Janeiro	3	5	2	1,67	U San Andres	1	16	1	16,00
17	U Andes Colombia	2	25	1	12,50	U Americas Puebla	2	9	1	4,50
18	U Americas Puebla	1	19	1	19,00	U Santa Cruz Sierra	1	7	1	7,00
19	Austral U	2	18	1	9,00	U Piura	1	7	1	7,00
20	U Torcuato di Tella	4	17	1	4,25	Federal U Ceara	1	7	1	7,00

Brazil obtains the most significant results in MK with nine institutions although the top two universities are from Chile. There is a lot of dispersion in BSIM being Mexico in the first position with four institutions in the list and having the top two universities. Chile and Brazil also have four institutions in the ranking.

The following analysis presents the leading universities in Finance (FIN) and Organization Studies (OS). The results appear in Table 8.

FIN is an important topic in Latin America because it shows a high production volume. Brazil has nine institutions in the list although Chile has the first and the third one with very significant figures. Argentina and Brazil are the countries with most universities in the BSIM list with five. However, none of the Argentinean universities enter the Top 10. Chile has four institutions including the first and fourth one. Mexico also has four institutions in the list.

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Table 8 Leading institutions in FIN and OS

	Finance					Organization Studies				
R	**Institution**	**TP**	**TC**	**H**	**C/P**	**Institution**	**TP**	**TC**	**H**	**C/P**
1	Catholic U Chile	36	304	9	8,44	U Chile	8	240	5	30,00
2	ITAM Mexico	22	272	7	12,36	Federal U Minas Gerais	8	134	4	16,75
3	U Chile	51	222	7	4,35	Metro Aut U Mexico	4	57	3	14,25
4	U Sao Paulo	17	96	7	5,65	Catholic U Chile	3	200	2	66,67
5	U Torcuato di Tella	13	150	5	11,54	Tec Monterrey	3	43	2	14,33
6	Austral U	6	152	4	25,33	IBMEC Sao Paulo	4	38	2	9,50
7	U Republic Uruguay	8	98	4	12,25	ITAM Mexico	3	35	2	11,67
8	U Brasilia	8	29	4	3,63	UNAM Mexico	2	14	2	7,00
9	FGV Brazil	13	23	4	1,77	U Alberto Hurtado	2	7	2	3,50
10	Federal U Rio de Janeiro	13	56	3	4,31	U Andes Colombia	5	6	2	1,20
11	Catholic U Rio de Janeiro	14	52	3	3,71	U Santiago Chile	1	38	1	38,00
12	U San Andres	6	29	3	4,83	Austral U	1	13	1	13,00
13	Catholic U Brasilia	16	28	3	1,75	U Buenos Aires	4	12	1	3,00
14	U Andes Colombia	11	25	3	2,27	Universidad Belgrano	3	11	1	3,67
15	U Alberto Hurtado	4	22	3	5,50	Federal U Parana	1	7	1	7,00
16	Tec Monterrey	6	20	3	3,33	Catholic U Rio de Janeiro	1	6	1	6,00
17	Catholic U Peru	4	15	3	3,75	Tec Inst Santo Domingo	1	5	1	5,00
18	U Argentina Empresa	2	106	2	53,00	U Cema	1	5	1	5,00
19	Catholic U Rio de Janeiro	2	63	2	31,50	Nat U General Sarmiento	1	5	1	5,00
20	UNAM Mexico	7	47	2	6,71	Federal U Rio de Janeiro	3	4	1	1,33

Next, let us focus on Operations Research (OR) and Management Information Systems (MIS). Table 9 presents the Top 20 universities in these two categories.

Together with GM, OR is the category with the highest number of publications in Latin America. The University of Chile is the leading institution in this field although only three Chilean universities enter the list. Brazil is the country with more institutions in OR with ten. Mexico has four and Colombia two. The number of articles in MIS is very low in Latin America because only twenty-six universities have published at least one study and none of them have more than three publications. Brazil has seven institutions in the list and Chile six. Venezuela has three universities and Colombia two.

Table 9 Leading institutions in OR and MIS

	Operations Research					Management Information Systems				
R	**Institution**	**TP**	**TC**	**H**	**C/P**	**Institution**	**TP**	**TC**	**H**	**C/P**
1	U Chile	73	928	22	12,71	Federal U Rio Grande do Sul	2	96	2	48,00
2	U Sao Paulo	64	628	14	9,81	U Chile	3	32	2	10,67
3	Federal U Rio de Janeiro	58	667	14	11,50	U Sao Paulo	3	10	2	3,33
4	U Estadual Campinas	48	668	14	13,92	U Vale Rio do Sinos Unisinos	3	13	2	4,33
5	Catholic U Chile	47	378	10	8,04	U Carabobo	2	16	2	8,00
6	Federal U Fluminense	37	308	9	8,32	FGV Brazil	1	30	1	30,00
7	Tec Monterrey	23	260	8	11,30	Nat U Mar del Plata	1	17	1	17,00
8	Federal U Pernambuco	21	205	10	9,76	U Andes Colombia	1	14	1	14,00
9	Federal U Sao Carlos	21	260	9	12,38	U Central Venezuela	1	12	1	12,00
10	Catholic U Rio de Janeiro	20	307	8	15,35	Federal U Minas Gerais	2	11	1	5,50
11	Federal U Minas Gerais	20	158	7	7,90	U Concepcion	1	11	1	11,00
12	U Andes Colombia	19	124	5	6,53	Catholic U Chile	1	7	1	7,00
13	U Buenos Aires	17	53	2	3,12	Simon Bolivar U	1	6	1	6,00
14	ITAM Mexico	15	80	6	5,33	Adolfo Ibañez U	1	4	1	4,00
15	Federal U Santa Catarina	15	152	6	10,13	U Brasilia	1	3	1	3,00
16	U Estadual Paulista	14	79	4	5,64	Catholic U Rio Grande do Sul	1	2	1	2,00
17	Federal U Rio Grande do Sul	14	89	6	6,36	U Quindio	1	2	1	2,00
18	Adolfo Ibañez U	13	177	5	13,62	Aut U San Luis Potosi	1	1	1	1,00
19	U Americas Puebla	12	151	7	12,58	U Bio Bio	1	1	1	1,00
20	U Republic Uruguay	12	64	4	5,33	U T Federico Santa Maria	1	1	1	1,00

Finally, let us end this Section analyzing the leading institutions in Accounting (ACC), Human Resource Management (HRM) and in Spanish and Portuguese Journals indexed in WoS. Table 10 presents the results. Note that since the publication volume is very low in ACC and HRM, only the Top 10 institutions appear in the list for these categories.

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Table 10 Leading institutions in ACC, HRM and SPJ

	Accounting					Spanish and Portuguese Journals				
R	**Institution**	**TP**	**TC**	**H**	**C/P**	**Institution**	**TP**	**TC**	**H**	**C/P**
1	Tec Monterrey	1	11	1	11,00	U Sao Paulo	98	33	3	0,34
2	U Alberto Hurtado	1	10	1	10,00	U Chile	31	6	2	0,19
3	U Chile	3	7	1	2,33	U Tarapaca	7	5	2	0,71
4	U Las Americas Puebla	1	4	1	4,00	FGV Brasil	4	4	2	1,00
5	Catholic U Chile	1	2	1	2,00	U Zulia	162	8	1	0,05
6	U San Andres	1	1	1	1,00	Federal U Santa Catarina	24	6	1	0,25
7	U Sao Paulo	4	0	0	0,00	Adolfo Ibañez U	11	6	1	0,55
8	Federal U Rio Grande do Sul	2	0	0	0,00	Catholic U Minas Gerais	8	5	1	0,63
9	ITAM Mexico	1	0	0	0,00	U Vale Rio do Sinos Unisinos	11	4	1	0,36
10	U Veracruzana	1	0	0	0,00	Federal U Minas Gerais	23	3	1	0,13
	Human Resource Management					Federal U Pernambuco	19	3	1	0,16
1	U Sao Paulo	8	75	4	9,38	Federal U Rio Grande do Sul	19	3	1	0,16
2	Tec Monterrey	5	59	3	11,80	U Nove de Julho	14	3	1	0,21
3	Catholic U Peru	3	22	2	7,33	Federal U Parana	12	3	1	0,25
4	ITAM Mexico	5	6	2	1,20	U Brasilia	9	3	1	0,33
5	U Estadual Campinas	1	30	1	30,00	U Estadual Campinas	9	3	1	0,33
6	U Brasilia	1	7	1	7,00	Catholic U Parana	6	3	1	0,50
7	IBMEC Sao Paulo	1	5	1	5,00	Federal U Bahia	6	3	1	0,50
8	Federal U Bahia	1	5	1	5,00	Federal U Fluminense	6	3	1	0,50
9	Federal U Minas Gerais	1	5	1	5,00	Catholic U Rio de Janeiro	16	2	1	0,13
10	Federal U Rio Grande do Sul	1	5	1	5,00					

The figures in ACC are the lowest ones of all the categories with less than twenty articles in all Latin America. Only the University of Chile, the University of Sao Paulo and the Federal University of Rio Grande do Sul have published more than one article in this field. In HRM the figures are higher than ACC but still very low. Brazil leads the list with seven institutions and having the University of Sao Paulo in the first position. In SPJ, the University of Sao Paulo also leads the ranking. Note that the University of Zulia has the highest number of articles because it controls the Revista de Ciencias Sociales where it publishes most of its articles. Brazil has sixteen universities in the Top 20. The main reason for this is because it dominates in the Portuguese journals.

3.3. Temporal analysis of the leading institutions

The leading universities change throughout time because the World is dynamic and it depends on the specific results of each year that may be conditioned by a wide range of factors. Therefore, the aim of this section is to identify the influence of Latin-American universities in business and management and see how the leading positions have changed across time. First, let us look into the leading universities in Latin America by dividing the global results in periods of five years. Table 11 presents the results for 1990-1994.

Table 11 Leading Latin-American institutions between 1990-1994

			Top 102 Journals						All Journals			
R	**University**	**Cou**	**TP**	**TC**	**H**	**C/P**	**T8**	**T41**	**TP**	**TC**	**H**	**C/P**
1	Federal U Rio de Janeiro	BRA	7	82	4	11,71	0	3	9	93	5	10,33
2	Catholic U Chile	CHL	5	82	4	16,40	0	2	5	68	3	13,60
3	U Chile	CHL	7	76	4	10,86	1	5	7	76	4	10,86
4	U Sao Paulo	BRA	5	38	3	7,60	0	2	10	38	3	3,80
5	U Estadual Campina	BRA	3	59	2	19,67	0	2	6	63	3	10,50
6	Adolfo Ibañez U	CHL	1	148	1	148,00	1	1	1	148	1	148,00
7	National U San Luis	ARG	1	33	1	33,00	0	1	1	33	1	33,00
8	Catholic U Rio de Janeiro	BRA	1	20	1	20,00	0	1	3	20	1	6,67
9	U Americas Puebla	MEX	1	19	1	19,00	0	0	1	19	1	19,00
10	Tec Monterrey	MEX	1	8	1	8,00	0	0	3	11	2	3,67
11	Federal U Mato Grosso	BRA	1	7	1	7,00	0	0	1	7	1	7,00
12	Federal U Parana	BRA	1	7	1	7,00	0	1	1	7	1	7,00
13	U Central Venezuela	VEN	1	7	1	7,00	0	1	1	7	1	7,00
14	Tec Inst Santo Domingo	DR	1	5	1	5,00	0	1	1	5	1	5,00
15	IESA	VEN	1	5	1	5,00	0	0	1	5	1	5,00
16	Federal U Juiz de Fora	BRA	1	3	1	3,00	0	1	1	3	1	3,00
17	IPADE	MEX	1	0	0	0,00	0	0	1	0	0	0,00
18	Pan U City Mexico	MEX	1	0	0	0,00	0	0	1	0	1	0,00
19	U Andes Venezuela	VEN	1	0	0	0,00	0	1	1	0	1	0,00

In this period, only five universities, three from Brazil and two from Chile, presents remarkable results. Note that only twenty institutions have at least one article in the Top 102 journals. Table 12 shows the results found in WoS between 1995 and 1999.

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Table 12 Leading Latin-American institutions between 1995-1999

			Top 102 Journals						All Journals			
R	**University**	**Cou**	**TP**	**TC**	**H**	**C/P**	**T8**	**T41**	**TP**	**TC**	**H**	**C/P**
1	U Chile	CHL	12	545	11	45,42	2	10	19	692	14	36,42
2	Catholic U Chile	CHL	9	243	7	27,00	1	4	13	269	8	20,69
3	U Sao Paulo	BRA	9	120	6	13,33	0	2	14	141	7	10,07
4	U Estadual Campinas	BRA	10	88	6	8,80	0	7	12	131	7	10,92
5	Federal U Rio Grande do Sul	BRA	7	230	5	32,86	0	3	7	230	5	32,86
6	ITAM Mexico	MEX	8	218	5	27,25	0	5	11	392	7	35,64
7	Federal U Sao Carlos	BRA	5	121	5	24,20	0	2	5	121	5	24,20
8	Tec Monterrey	MEX	4	260	4	65,00	0	2	9	311	6	34,56
9	Federal U Rio de Janeiro	BRA	7	106	4	15,14	0	1	14	121	5	8,64
10	Adolfo Ibañez U	CHL	3	385	3	128,33	2	3	3	385	3	128,33
11	U Central Venezuela	VEN	5	27	3	5,40	0	5	5	27	3	5,40
12	INCAE Business School	CR	8	18	3	2,25	0	0	8	18	3	2,25
13	Federal U Minas Gerais	BRA	2	71	2	35,50	0	1	2	71	2	35,50
14	Federal U Santa Catarina	BRA	2	71	2	35,50	0	2	2	71	2	35,50
15	UNAM Mexico	MEX	2	50	2	25,00	0	1	4	86	4	21,50
16	Simon Bolivar U	VEN	10	47	2	4,70	0	10	10	47	2	4,70
17	U Andes Colombia	COL	2	28	2	14,00	0	1	4	40	3	10,00
18	U Concepcion	CHL	2	24	2	12,00	0	2	2	24	2	12,00
19	U Estadual Paulista	BRA	2	20	2	10,00	0	1	2	20	2	10,00
20	U Valle	COL	2	275	1	137,50	0	2	2	275	1	137,50
21	Benem U Aut Puebla	MEX	1	69	1	69,00	0	1	1	69	1	69,00
22	IESA	VEN	1	50	1	50,00	0	1	1	50	1	50,00
23	Tec Inst Santo Domingo	DR	1	28	1	28,00	0	1	1	28	1	28,00
24	Nat U Colombia	COL	1	15	1	15,00	0	0	3	34	2	11,33
25	U Americas Puebla	MEX	1	12	1	12,00	0	0	2	18	2	9,00
26	Federal U Espirito Santo	BRA	1	12	1	12,00	0	1	1	12	1	12,00
27	U Santiago Chile	CHL	1	12	1	12,00	0	1	1	12	1	12,00
28	U San Francisco de Quito	ECU	1	9	1	9,00	0	0	1	9	1	9,00
29	U Buenos Aires	ARG	2	7	1	3,50	0	0	6	28	4	4,67
30	U The West Indies	JAM	1	5	1	5,00	0	0	1	5	1	5,00
31	FGV Brazil	BRA	2	3	1	1,50	0	0	2	3	1	1,50
32	U Iberoamericana	MEX	1	2	1	2,00	0	1	1	2	1	2,00
33	U Andes Venezuela	VEN	1	2	1	2,00	0	0	11	23	2	2,09
34	Catholic U Rio de Janeiro	BRA	1	1	1	1,00	0	1	5	23	3	4,60
35	U Brasilia	BRA	1	1	1	1,00	0	1	1	1	1	1,00
36	Metro U Caracas	VEN	1	0	1	0,00	0	0	1	0	1	0,00
37	Nat U San Luis	ARG	1	0	0	0,00	0	1	1	0	0	0,00

During this period, the number of articles increases significantly. The University of Chile and the Catholic University of Chile lead the ranking although Brazil has more universities in the ranking. It is worth noting that only Brazil, Chile and Mexico have institutions in the Top 10. Next, Table 13 presents the leading institutions in the period 2000-2004.

Table 13 Leading Latin-American institutions between 2000-2004

			Top 102 Journals						All Journals			
R	**University**	**Cou**	**TP**	**TC**	**H**	**C/P**	**T8**	**T41**	**TP**	**TC**	**H**	**C/P**
1	U Chile	CHL	11	333	9	30,27	0	4	19	411	11	21,63
2	Federal U Rio de Janeiro	BRA	10	531	8	53,10	0	6	14	546	8	39,00
3	U Sao Paulo	BRA	14	379	7	27,07	0	6	19	422	9	22,21
4	U Estadual Campinas	BRA	11	219	7	19,91	0	7	15	224	7	14,93
5	Tec Monterrey	MEX	8	180	7	22,50	0	1	10	234	8	23,40
6	ITAM Mexico	MEX	10	180	6	18,00	2	4	15	226	9	15,07
7	Catholic U Chile	CHL	9	162	6	18,00	0	4	15	247	9	16,47
8	Federal U Minas Gerais	BRA	5	102	4	20,40	0	3	9	119	5	13,22
9	U Central Venezuela	VEN	5	51	4	10,20	0	4	5	51	4	10,20
10	U Brasilia	BRA	4	319	3	79,75	0	2	6	325	4	54,17
11	Federal U Sao Carlos	BRA	3	57	3	19,00	0	1	4	64	4	16,00
12	Federal U Pernambuco	BRA	3	49	3	16,33	0	2	3	49	3	16,33
13	Federal U Rio Grande do Sul	BRA	3	33	3	11,00	0	1	3	33	3	11,00
14	U Valle	COL	2	288	2	144,00	0	2	2	288	2	144,00
15	Austral U	ARG	3	147	2	49,00	1	1	4	1140	4	285,00
16	U West Indies	JAM	2	101	2	50,50	0	1	1	9	1	9,00
17	Aut U Sinaloa	MEX	2	74	2	37,00	0	2	2	74	2	37,00
18	UNAM Mexico	MEX	2	65	2	32,50	0	2	2	65	2	32,50
19	Federal U Fluminense	BRA	2	65	2	32,50	0	2	3	65	2	21,67
20	Metropolitan Aut U Mexico	MEX	3	23	2	7,67	0	2	4	46	3	11,50
21	FGV Brazil	BRA	1	43	1	43,00	0	1	1	43	1	43,00
22	U Torcuato Tella	BRA	1	36	1	36,00	0	0	2	39	2	19,50
23	Col Mexico	MEX	1	24	1	24,00	0	1	3	26	1	8,67
24	IPN Mexico	MEX	1	18	1	18,00	0	0	1	18	1	18,00
25	Federal U Espirito Santo	BRA	1	18	1	18,00	0	1	2	5	2	2,50
26	U Estadual Ceara	BRA	1	17	1	17,00	0	1	1	17	1	17,00
27	U Talca	CHL	1	17	1	17,00	0	1	1	17	1	17,00
28	Catholic U Parana	BRA	1	13	1	13,00	0	0	1	13	1	13,00
29	Nat U Colombia	COL	1	13	1	13,00	0	0	3	24	2	8,00
30	Simon Bolivar U	VEN	1	11	1	11,00	0	1	1	11	1	11,00
31	U Andes Colombia	COL	3	10	1	3,33	0	1	9	22	3	2,44
32	Benem U Aut Puebla	MEX	1	9	1	9,00	0	1	2	47	2	23,50
33	U San Andres	ARG	1	9	1	9,00	0	1	1	9	1	9,00
34	Catholic U Rio de Janeiro	BRA	1	8	1	8,00	1	1	4	50	3	12,50
35	Adolfo Ibañez U	CHL	3	7	1	2,33	0	0	3	20	2	6,67
36	Nat U San Luis	ARG	2	7	1	3,50	0	2	2	7	1	3,50
37	U Estadual Ponta Grossa	BRA	1	7	1	7,00	0	1	1	7	1	7,00
38	U Estadual Sudoeste Bahía	BRA	3	4	1	1,33	0	0	3	4	1	1,33
39	U Santiago Chile	CHL	1	4	1	4,00	0	1	2	26	1	13,00
40	U Americas Puebla	MEX	1	4	1	4,00	1	1	2	47	2	23,50

The University of Chile is the leading one although the Federal University of Rio de Janeiro and the University of Sao Paulo obtain very similar results. Table 14 shows the results for 2005-2009.

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Table 14 Leading Latin-American institutions between 2005-2009

			Top 102 Journals						All Journals			
R	**University**	**Cou**	**TP**	**TC**	**H**	**C/P**	**T8**	**T41**	**TP**	**TC**	**H**	**C/P**
1	U Sao Paulo	BRA	28	727	13	25,96	1	19	65	669	10	10,29
2	Tec Monterrey	MEX	24	505	12	21,04	0	10	41	513	12	12,51
3	Catholic U Chile	CHL	29	543	11	18,72	2	12	35	590	12	16,86
4	U Chile	CHL	13	368	9	28,31	0	8	40	533	11	13,33
5	Federal U Rio de Janeiro	BRA	25	351	9	14,04	1	14	28	160	6	5,71
6	U Estadual Campinas	BRA	15	294	9	19,60	0	13	18	299	9	16,61
7	Austral U	ARG	10	229	8	22,90	0	4	10	229	8	22,90
8	Federal U Minas Gerais	BRA	12	211	8	17,58	1	10	20	127	5	6,35
9	Federal U Rio Grande do Sul	BRA	9	220	7	24,44	0	3	19	222	7	11,68
10	Adolfo Ibañez U	CHL	8	118	7	14,75	0	3	14	158	9	11,29
11	Federal U Fluminense	BRA	9	114	6	12,67	0	8	11	134	6	12,18
12	IBMEC Sao Paulo	BRA	6	142	5	23,67	0	5	8	157	6	19,63
13	INCAE Business School	CR	13	57	5	4,38	0	1	18	57	5	3,17
14	ITAM Mexico	MEX	4	110	4	27,50	0	2	13	184	6	14,15
15	Catholic U Rio de Janeiro	BRA	5	79	4	15,80	0	5	6	148	4	24,67
16	U Andes Chile	CHL	4	53	4	13,25	0	1	5	64	5	12,80
17	U Andes Colombia	COL	7	84	3	12,00	0	4	18	79	4	4,39
18	Federal U Sao Carlos	BRA	4	67	3	16,75	0	3	6	68	3	11,33
19	U Buenos Aires	ARG	5	58	3	11,60	0	4	10	61	3	6,10
20	IPN Mexico	MEX	4	50	3	12,50	0	3	5	62	4	12,40
21	U Americas Puebla	MEX	4	48	3	12,00	0	4	52	5	4	0,10
22	Catholic U Peru	Peru	4	43	3	10,75	0	0	12	83	6	6,92
23	U Met Piracicaba	BRA	3	21	3	7,00	0	0	4	22	3	5,50
24	Nat U Colombia	COL	3	18	3	6,00	0	3	4	20	3	5,00
25	FGV Brazil	BRA	4	14	3	3,50	0	1	6	32	4	5,33
26	U Estadual Paulista	BRA	3	44	2	14,67	0	3	3	44	2	14,67
27	Federal U Pernambuco	BRA	3	38	2	12,67	0	0	11	71	4	6,45
28	U Presb Mackenzie	BRA	3	25	2	8,33	0	2	3	7	1	2,33
29	Federal U Santa Catarina	BRA	2	36	2	18,00	0	1	2	36	2	18,00
30	U San Andres	ARG	2	33	2	16,50	0	1	9	49	3	5,44
31	U Diego Portales	CHL	2	31	2	15,50	0	0	2	31	2	15,50
32	Aut U Sinaloa	MEX	2	30	2	15,00	0	2	2	30	2	0,00
33	Simon Bolivar U	VEN	2	27	2	13,50	0	1	5	7	1	1,40
34	U Concepcion	CHL	2	27	2	13,50	0	2	5	33	3	0,00
35	Catholic U Brasilia	BRA	2	25	2	12,50	0	2	2	25	2	12,50
36	Benem U Aut Puebla	MEX	2	17	2	8,50	0	2	2	0	0	0,00
37	U Juarez State Durango	MEX	2	9	2	4,50	0	2	2	9	2	4,50
38	U Republic Uruguay	URU	2	8	2	4,00	0	0	2	8	2	4,00
39	U Anahuac	MEX	2	7	2	3,50	0	0	2	7	2	3,50
40	U Vale Rio Dos Sinos Unisinos	BRA	2	38	1	19,00	0	2	2	38	1	19,00

The number of articles continues to growth being the University of Sao Paulo the first institution in the ranking. Brazil continues to have the highest number of institutions in the list. Table 15 presents the results for the last period: 2010-2014.

Table 15 Leading Latin-American institutions between 2010-2014

			Top 102 Journals						All Journals			
R	**University**	**Cou**	**TP**	**TC**	**H**	**C/P**	**T8**	**T41**	**TP**	**TC**	**H**	**C/P**
1	U Sao Paulo	BRA	45	161	7	3,58	1	14	168	301	9	1,79
2	Catholic U Chile	CHL	40	153	7	3,83	3	21	62	170	7	2,74
3	U Andes Colombia	COL	28	110	6	3,93	0	8	60	133	6	2,22
4	Tec Monterrey	MEX	19	112	5	5,89	0	7	49	155	6	3,16
5	U Chile	CHL	38	108	5	2,84	4	19	120	215	7	1,79
6	Federal U Pernambuco	BRA	8	95	5	11,88	0	1	36	172	9	0,00
7	Adolfo Ibañez U	CHL	21	68	5	3,24	1	10	54	107	5	1,98
8	Federal U Minas Gerais	BRA	13	58	4	4,46	0	6	43	63	5	1,47
9	Austral U	ARG	7	47	4	6,71	2	5	9	51	4	5,67
10	Federal U Rio Grande do Sul	BRA	11	38	4	3,45	0	7	36	67	5	1,86
11	Federal U Santa Catarina	BRA	8	38	4	4,75	0	6	39	71	5	1,82
12	U Brasilia	BRA	10	66	4	6,60	0	2	33	90	5	2,73
13	Catholic U Peru	Peru	8	28	4	3,50	0	1	34	101	6	2,97
14	Catholic U Brasilia	BRA	8	42	3	5,25	0	1	18	60	4	3,33
15	Federal U Rio de Janeiro	BRA	13	39	3	3,00	0	7	58	77	4	1,33
16	Federal U Paraiba	BRA	5	34	3	6,80	0	3	11	37	3	3,36
17	Aut U Nuevo León	MEX	8	30	3	3,75	0	6	12	32	3	2,67
18	Catholic U Rio de Janeiro	BRA	20	29	3	1,45	0	5	40	63	5	1,58
19	Pan U City México	MEX	5	27	3	5,40	0	3	5	27	3	5,40
20	ITAM Mexico	MEX	7	25	3	3,57	1	5	28	47	4	1,68
21	Federal U Sao Carlos	BRA	7	23	3	3,29	0	4	27	43	5	1,59
22	U San Andres	ARG	4	23	3	5,75	1	2	4	23	3	5,75
23	U Americas Puebla	MEX	3	11	3	3,67	0	2	6	11	3	1,83
24	U Estadual Paulista	BRA	8	26	2	3,25	0	5	23	59	4	2,57
25	INCAE Business School	CR	14	23	2	1,64	0	0	29	31	2	1,07
26	Metro Aut U Mexico	MEX	6	23	2	3,83	1	3	11	54	4	4,91
27	U Diego Portales	CHL	4	22	2	5,50	0	1	13	26	3	2,00
28	Aut U Sinaloa	MEX	3	21	2	7,00	0	3	3	21	2	7,00
29	IPADE Business School	MEX	4	19	2	4,75	0	2	4	19	2	4,75
30	U North - Chile	COL	4	17	2	4,25	0	1	6	21	3	3,50
31	U Republic Uruguay	URU	5	16	2	3,20	0	3	17	40	4	2,35
32	U Talca	CHL	6	9	2	1,50	0	5	13	38	4	2,92
33	IPN Mexico	MEX	3	8	2	2,67	0	1	6	14	13	2,33
34	U Desarrollo	CHL	5	7	2	1,40	0	0	14	27	3	1,93
35	FUCAPE	BRA	3	7	2	2,33	0	0	9	7	2	0,78
36	Tec Inst Celaya	MEX	3	20	1	6,67	0	0	3	20	1	6,67
37	U Presb Mackenzie	BRA	3	8	1	2,67	0	0	15	8	1	0,53
38	Nat U General Sarmiento	ARG	3	6	1	2,00	0	1	11	11	2	1,00
39	U The West Indies	JAM	7	5	1	0,71	0	0	16	35	2	2,19
40	FGV Brazil	BRA	3	4	1	1,33	0	5	11	14	2	1,27

Again the University of Sao Paulo is the leading institution in the ranking and Brazil has thirteen universities in the Top 25. During this period, it is worth noting the growth of the University of the Andes in Colombia that obtains the third position and clearly shows its relevance in the future as one of the institutions in Latin America. Another remarkable growth comes from the Adolfo Ibanez University which currently obtains the seventh position and clearly shows its potential in order to become a Top 3 university in business and management in Chile.

In general, the results are in accordance with the global ranking shown in Table 3. However, it is remarkable the strong growth seen throughout time that will probably continue in the future together with the economic development of the region. In order to see more specifically how the number of articles has increased throughout time, let us look into the annual number of studies published by the Top 30 institutions in Latin America. Table 16 presents the annual evolution for the Top 102 journals.

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Table 16 Annual evolution of Latin-American publications in the Top 102 business and management journals

Country	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	Total
U Chile	0	2	3	0	2	1	3	2	4	2	1	1	1	4	4	3	2	2	3	3	5	7	5	9	12	81
U Sao Paulo	0	1	1	0	3	3	1	0	3	2	4	1	4	4	1	8	4	7	4	5	8	10	6	10	11	101
Catholic U Chile	0	0	1	2	2	0	1	1	5	2	1	2	3	1	2	6	3	7	9	4	8	8	4	14	6	92
Federal U Rio de Janeiro	3	1	2	1	0	2	1	1	2	1	4	0	1	3	2	2	2	10	4	7	4	1	2	4	2	62
Tec Monterrey	0	0	0	1	0	1	0	0	0	3	2	1	3	1	1	3	6	4	6	5	4	3	6	4	2	56
U Estadual Campinas	0	1	1	1	0	1	1	2	2	4	2	5	1	2	1	2	5	2	6	0	2	3	3	3	1	51
ITAM Mexico	0	0	0	0	0	0	0	4	2	2	0	2	2	2	4	0	1	0	1	0	0	2	1	2	2	27
Federal U Rio Grande do Sul	0	0	0	0	0	1	0	0	3	3	1	0	0	1	1	0	0	1	4	4	1	3	4	0	3	30
Federal U Minas Gerais	0	0	0	0	0	1	0	0	0	1	1	2	0	1	1	2	1	4	5	0	1	2	4	2	2	30
Adolfo Ibañez U	1	0	0	0	0	1	1	0	1	0	2	1	0	1	0	0	1	3	2	3	5	2	4	6	7	41
Federal U Sao Carlos	0	0	0	0	0	1	1	0	1	2	0	1	1	1	0	1	0	1	0	2	2	0	3	0	2	19
Austral U	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	3	0	6	2	1	2	0	2	20
Federal U Fluminense	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	3	3	2	1	1	3	4	4	24
U Andes Colombia	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	0	1	1	2	3	4	3	0	13	8	39
Federal U Pernambuco	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	2	0	4	0	2	14
INCAE Business School	0	0	0	0	0	1	0	1	0	1	5	0	1	0	1	0	7	0	1	2	0	4	2	2	6	34
Catholic U Rio de Janeiro	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2	1	2	0	2	1	7	2	8	27
U Central Venezuela	0	0	0	1	0	1	0	0	1	1	1	0	2	0	2	0	0	1	0	0	0	0	0	0	1	11
U Brasilia	0	0	0	0	0	0	0	1	0	0	1	0	2	1	0	0	0	0	0	0	3	1	1	3	2	15
Federal U Santa Catarina	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	1	0	1	0	1	0	3	3	1	13
Aut U Sinaloa	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	1	0	1	0	7
IBMEC Sao Paulo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	1	0	0	0	0	7
Metro Aut U Mexico	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	1	2	0	1	0	1	3	2	0	0	13
U Republic Uruguay	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	1	1	0	1	2	10
U Americas Puebla	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	2	1	0	0	1	0	1	1	0	9
Simón Bolivar U	0	0	0	0	0	0	1	9	0	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0	1	15
U Estadual Paulista	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	6	13
U Buenos Aires	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	2	0	0	1	1	0	0	1	1	1	10
IPN Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2	1	0	2	0	0	7
Catholic U Peru	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3	0	3	0	12
U-index	**1**	**1**	**2**	**1**	**2**	**2**	**1**	**2**	**3**	**3**	**3**	**2**	**3**	**3**	**2**	**3**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**6**	**16**

Table 17 Annual evolution of Latin-American publications in business and management

Country	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	Total
U Chile	0	2	3	0	2	1	7	3	5	3	1	3	2	8	5	6	10	6	12	10	10	24	25	20	36	204
U Sao Paulo	0	6	1	0	3	3	4	0	0	2	0	2	6	5	2	11	8	9	21	33	26	34	32	38	38	284
Catholic U Chile	1	0	1	1	0	1	1	3	5	3	1	6	5	1	2	6	5	10	14	5	11	12	10	18	11	133
Federal U Rio de Janeiro	3	1	2	2	1	2	1	4	2	5	4	1	2	3	4	2	4	0	9	15	10	10	12	13	13	125
Tec Monterrey	1	0	0	1	1	2	0	1	1	5	3	2	3	0	1	7	8	8	11	13	14	6	10	9	10	117
U Estadual Campinas	1	2	1	2	0	1	2	2	2	0	2	5	2	2	4	3	6	2	6	1	4	10	7	8	12	87
ITAM Mexico	0	1	0	3	1	0	1	4	3	3	2	4	3	2	4	1	4	0	2	1	2	6	6	9	5	67
Federal U Rio Grande do Sul	0	0	1	0	0	1	0	0	3	3	1	0	0	1	1	0	0	3	7	11	1	9	7	4	15	68
Federal U Minas Gerais	0	0	0	0	0	1	0	0	0	1	3	3	1	1	1	0	1	5	11	8	10	8	13	7	5	79
Adolfo Ibañez U	1	0	0	0	0	1	1	0	1	0	3	1	0	1	0	0	2	3	6	5	7	6	11	13	21	83
Federal U Sao Carlos	0	0	1	0	0	1	1	0	1	2	0	1	2	1	0	1	1	1	1	2	3	2	7	4	11	43
Austral U	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	0	1	3	0	6	3	1	3	0	2	23
Federal U Fluminense	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2	1	0	3	3	4	6	4	6	10	7	48
U Andes Colombia	0	0	0	0	1	0	1	2	0	1	0	4	2	1	2	1	2	6	5	6	13	6	5	20	16	94
Federal U Pernambuco	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	1	4	0	8	8	9	3	8	45
INCAE Business School	0	0	0	0	0	1	0	6	0	1	5	0	1	0	1	0	7	2	1	6	1	6	2	7	13	60
Catholic U Rio de Janeiro	0	0	0	1	1	0	0	0	0	0	0	0	3	1	0	2	3	1	4	1	6	1	15	5	13	57
U Central Venezuela	0	0	0	1	0	1	0	2	1	1	1	0	2	0	2	0	0	1	2	2	2	3	2	2	1	26
U Brasilia	0	0	1	0	0	0	0	1	0	0	1	1	2	1	1	2	0	0	4	1	7	9	6	8	3	48
Federal U Santa Catarina	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	1	0	3	5	9	7	7	6	10	51
Aut U Sinaloa	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	1	0	1	0	7
IBMEC Sao Paulo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	2	1	0	0	0	0	9
Metro Aut U Mexico	0	0	0	0	0	0	0	0	0	1	1	2	0	1	0	1	0	1	1	2	5	6	3	0	0	24
U Republic Uruguay	0	0	0	0	0	0	0	0	0	0	1	1	3	0	0	0	2	2	1	2	5	1	1	4	6	29
U Americas Puebla	0	0	0	1	0	0	0	1	1	0	0	0	1	1	0	1	3	1	2	1	1	0	3	1	1	19
Simón Bolivar U	0	0	0	0	0	0	1	9	0	0	0	0	0	1	0	1	0	3	0	2	3	2	1	1	1	25
U Estadual Paulista	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	4	2	4	4	9	28
U Buenos Aires	0	0	2	0	0	2	0	0	4	0	1	2	0	0	1	2	4	0	1	3	2	6	0	11	3	44
IPN Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	2	3	0	2	1	0	12
Catholic U Peru	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	7	12	5	7	2	45
U-index	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**4**	**3**	**3**	**3**	**4**	**3**	**3**	**4**	**4**	**5**	**5**	**7**	**6**	**8**	**8**	**9**	**9**	**11**	**27**

As we can see, in the nineties, the number of articles is very low and almost no institution publishes in the Top 102 journals. Only the Top 4 regularly publish some work in these journals. During the first decade of the millennium the numbers increase considerably although they are still very low. However, now more universities publish regularly some studies in the top journals. The strongest increase occurs during the last five years where the Top 3 institutions publish a considerable number of articles every year and the rest start to increase their figures. Sometimes, this increase because significant such as the case of the Adolfo Ibanez University and the University of the Andes in Colombia.

Next, let us focus on all the journals available in WoS in the categories of Business, Business Finance and Management. Table 17 shows the results.

Here the numbers are bigger than Table 16 although still very low. In the nineties, there were not many universities publishing in leading international journals. In general, the annual number of articles increases throughout time although quite slow until the last ten years where the growth becomes remarkable for the top universities. Currently, there are more than ten Latin-American institutions that publish more than ten articles in Business, Business Finance and Management every year in WoS.

In this context, we could suggest a new index for evaluating a set of articles that we call the University – index (U-index). This index measures the connecting point between the X number of universities that publish at least X articles. Therefore, for the year 2014, the U-index is 11 because eleven Latin-American universities have published 11 articles or more. In previous years, the numbers were lower as it is seen in Tables 16 and 17. Note that the global U-index for the Top 102 journals according to Table 3 is 16 because between 1990 and 2014, sixteen universities have published sixteen or more articles in the Top 102. For all the journals available in WoS, the U-index is 27.

The main advantage of this indicator is that it shows the number of universities reaching a certain publication threshold. And this is very useful in order to compare the productivity of institutions between countries or regions. Observe that similar extensions of the U-index could be developed by using other local and global indicators (Emrouznejad & Marra, 2014) including the citations, the C/P ratio and the h-index. Moreover, it is also possible to apply this measure with authors, countries and journals.

3.4. Bibliographic coupling and co-authorship between Latin American universities

Finally, let us look into the citation structure of Latin American universities. For doing so, this Section studies the concepts of bibliographic coupling and co-authorship by using the VOS viewer software (Van Eck and Waltman, 2010). Bibliographic coupling is a similarity measure that uses citation analysis to identify the relationship between documents. Bibliographic coupling appears when two different studies reference a common third study

in their bibliographies (Martyn, 1964). This article analyzes bibliographic coupling from the university perspective where the connection is for universities that cite the same studies. Figure 1 shows the bibliographic coupling in the Latin American region. Note that the foreign universities co-authoring with Latin American institutions also appear in the graph.

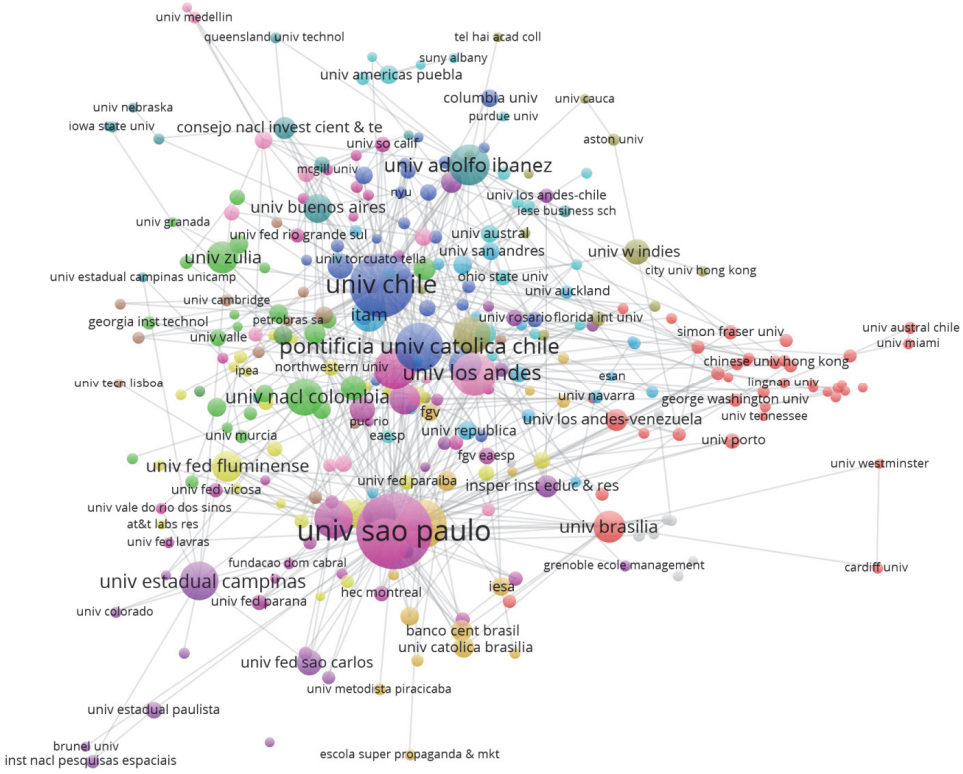

Fig. 1 Bibliographic coupling between Latin American universities including their foreign co-authors

The most productive universities have the highest influence in the analysis because they have more articles and therefore they also generate more citations. The University of Sao Paulo and the University of Chile are the most relevant universities with a very huge bibliographic network. Note that Figure 1 shows the 500 most significant connections between universities through the bibliographic coupling methodology.

Co-authorship is a useful technique for identifying the network between universities. Co-authorship measures the articles that are published jointly by different individuals or institutions. This article studies co-authorship from the university perspective where the objective is to identify the connection between Latin American institutions and their co-

authors. Figure 2 presents the co-authorship structure of the leading Latin American universities in business and management.

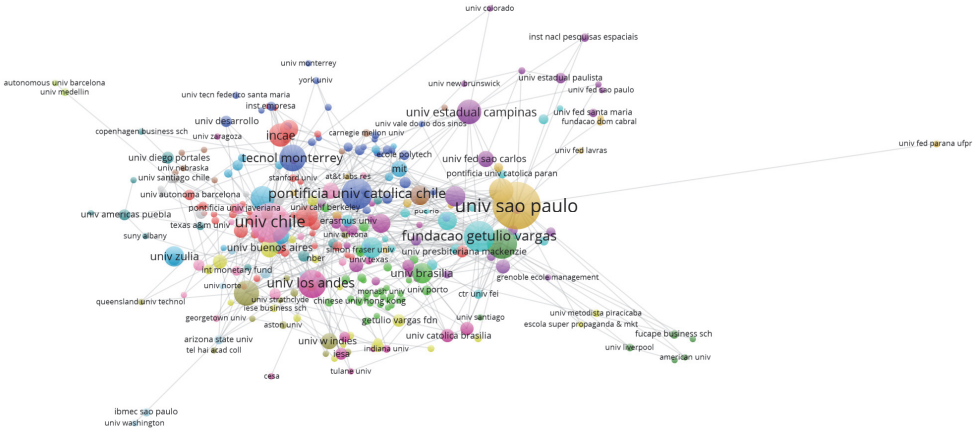

Fig. 2 Co-authorship between Latin American universities including their foreign co-authors

The leading universities in the region have the most remarkable co-authorship results. Similarly to Figure 1, the University of Sao Paulo and the University of Chile present the most significant results. Observe that Figure 2 also presents the 500 strongest co-authorship connections.

4. Conclusions

This work presents a general overview of the leading institutions in business and management research in Latin America between 1990 and 2014. The findings indicate that Brazil is the most relevant country in the region mainly because it is a very big country that encompasses one third of the Latin-American population. The University of Sao Paulo and the Federal University of Rio de Janeiro are in the Top 5 of the global ranking and 38% of the Top 50 universities are from this country. Chile gets the second position close to Mexico. The case of Chile is very remarkable because it is ten times smaller than Brazil and six times smaller than Mexico. His universities stand at a very high level in the region being the University of Chile the leading one in Latin America and the Catholic University of Chile the third one. Currently, there are nine Chilean universities in the Top 50. Mexico also obtains remarkable results having the Technological Institute of Monterrey and the ITAM in the Top 10. Mexico also has nine universities in the Top 50. The rest of the countries do not get very significant results having only a small number of universities in the list. Argentina, Colombia and Venezuela have three universities each in the Top 50 but none of them in the Top 10. In general, Latin-American institutions tend to collaborate

more with the USA and Europe. Inside Europe, the UK and Spain are the most connected countries with the region.

During the last years, the productivity of Latin-American universities in the leading business and management journals is increasing a lot, motivated mostly by a strong economic development of the economy that invests a lot in research. Focusing on topics, operations research is the most popular one in the region according to the number of articles in WoS journals. Finance, innovation and entrepreneurship and general management are also very relevant topics in Latin America. On the other hand, accounting, management information systems and human resource management are the topics with the lowest publication record by Latin-American institutions. It is worth noting that each country may have a different profile being more productive in different topics. For example, Brazil is the leader or has a very remarkable position in operations research, innovation and entrepreneurship, production and operations management, finance, organization studies, human resource management, management information systems, other business and management activities and Spanish and Portuguese journals. Chile does not have so many universities than Brazil but the University of Chile and the Catholic University of Chile are well placed in almost all the categories. For the rest of the countries, it is worth noting that the INCAE Business School of Costa Rica gets the first position in general management and the Technological Institute of Monterrey of Mexico gets the first place in production and operations management, business strategy and international management, other business and management activities and accounting.

Finally, let us mention some limitations worth noting for future research. First, this study only considers the articles that appear with Latin-American affiliation. However, it does not consider the works by authors currently working in Latin America that previously were working abroad if these studies appear with the foreign affiliation. Therefore, the results only focus on the Latin-American publications but do not take into account the whole labour force available in an institution. This issue is important because in business and management, most of the researchers of the region pursue a PhD in the USA or Europe and later come back to Latin America. Thus, many of their publications do not have a Latin-American affiliation although they are working in the region and their standards should be taken into account in order to measure the research quality of a university. Note that the aim of this study is to focus on the internal productivity of Latin America although this issue may condition the research quality of the institution.

Some other important limitations are those that affect the WoS methodology. For example, WoS gives one unit to any participating institution in an article without considering the total number of institutions of the study. Therefore, it encourages co-authorship because a work with one institution receives only one unit while another article with three universities receive three units. Although this issue is important, in general terms the collaboration

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network of most institutions is quite similar so there should not be important deviations between them when considering this limitation. Another problem is the quality of the journals. This study classified the journals in different groups in order to distinguish between the high-quality journals and the rest. However, it is not easy to measure the quality of the journals because many of them may be similar but with some differences that technically should produce different results. And in some cases, there may be important differences between journals. For example, the ranking is based on the Top 102 journals in business and management. But inside these 102 journals it is not the same to publish in the Top 5 or in the Top 90-102. Although the article shows additional indicators to solve this problem such as the number of publications in the Top 8 and Top 41 journals, this is an important limitation to remark.

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Stochastic valuation of innovative investments

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Abstract

This paper develops an investment valuation model based on Real Options methodology, arguing that this technique is the most appropriate in a context with uncertainty, flexibility and sunk costs. The model is built using stochastic calculus and solved by a numerical algorithm.

Keywords: *Real options, R&D valuation, stochastic valuation.*

Introduction

Governments are investing on R&D projects, yet investors require more information to take part into projects as some of them are not familiar with its complexities and expected future growth. There is a need for valuation methodologies that shows potential investors future benefits.

The available valuation methodologies can be classified into two main groups. On the one hand, the traditional ones, which involved costing and income calculations, and, on the other hand, innovative methods including real option for innovative project valuation (Schwartz, 2013; Trigeorgis, 1993). These projects encompass multiple sources of uncertainty and learning processes of different actors. The total cost of the investment is uncertain and each stage of the investment is subject to exogenous and endogenous sources of uncertainty, putting the completion of the project at risk.

Dixit and Pindyck (1994) argue that most investment decisions in innovative projects have three key features that demands the use of the methodology of real options instead of traditional approaches. Firstly, these investments are mostly irreversible (fully or partially). Secondly, there is uncertainty about the future return on the investment. Future prices of assets are unpredictable and profit flows are uncertain. Thirdly, investors have the option of waiting for better information about future prices (Pindyck, 1991; Brennan and Schwartz, 1985; Trigeorgis, 1993; McDonald and Siegel, 1986).

This work is organised in three sections. The first one, analyses the R&D stages of the project. The next one, discuss about the future market. The last one, proposes an algorithm for calculate the net present value of a R&D investment.

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1. R&D stages

An R&D project is a process of sequential investments; in which it is possible to abandon it each time a new contribution is needed. The duration of the project is divided into n stages. In each one, many tasks are carried out, generating a total expected cost (C_i^e). It is a learning process; every new money contribution reduces the remaining cost $c_i(t)$, modelled as a stochastic process with initial value C_i^e (See figure 1).

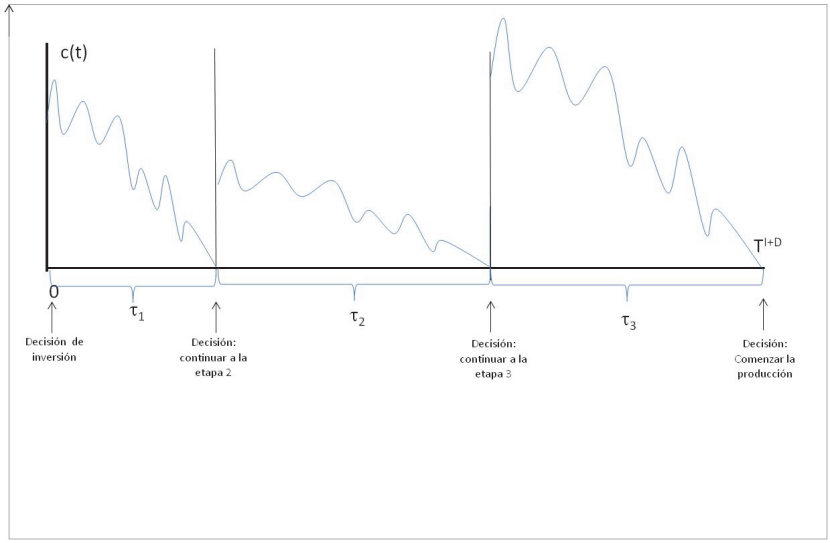

Fig.1 Remaining cost process and investment decision

Optimal stock management and allocation of inventory to orders will ensure greater customer satisfaction, stock optimization, cost reductions and maximization of company turnover. However, at a particular time, this optimal allocation may become less than ideal, due to unforeseen circumstances within the company. In this case a reallocation of inventory to orders will be necessary.

1.1. The remaining cost process

The remaining cost of stage i evolves from an initial value $C_i^e = c_i(0)$, following a stochastic process described by (Pindyck, 1993):

$$dc_i(t) = -Adt + \sigma_i\sqrt{Ac_i(t)}\,dz_i + \gamma c_i(t)dy \qquad (1)$$

Where I_i is the maximum investment rate for stage i.

$$A = \begin{cases} 0 & t < t^{i-1} \\ I_i & t^{i-1} \leq t \leq t^i \end{cases}$$

The first term of equation (1) shows how the remaining cost decreases with time, due to investment; the second one corresponds to what Pindyck (1993) calls technical uncertainty, and, the latter, concerns the uncertainty regarding raw materials and labour prices (assumed equal for all stages). Clearly, once this process reaches zero, the stage in question is terminated.

The commercial product is finished and ready for sale after all the stages have been completed successfully. So that $T = \sum_{i=1}^{n} \tau_i$ is a random variable that represents the time needed to launch the product to the market.

1.2. Technical failure

Moreover, in each stage there is a possibility of technical failure that is modelled using a Poisson process of parameter λ_i. According to Schwartz (2004), this possibility of failure is modelled using a modified rate of discount $(r - \lambda_i)$.

2. The market

Once the product has been developed and the factory installed for its manufacture, the new challenge is to conquer market. Usually investors patent their invention, so, meanwhile this patent is alive the market is a monopoly. However, after its expiration, the company will enter into perfect competition.

2.1. The selling process

Every product has a life cycle. Sales start to rise from an initial value with low profits (competition is low) and the market begins to build from marketing campaigns. After a while, the benefit grows relatively fast in a context protected by a patent, until it reaches a maximum. Finally, it falls due to a context of increasing competition. The proposed sales diffusion process is inspired by the work of Frank Bass (2004). Buyers follow two possible behaviors, either adopt spontaneously or, after a while, imitate the former and buy.

Initial sales volume, $n(0)$, is equal to the expected total sales over the life cycle (m) multiplied by a coefficient representing the independent adoption rate (p). Then, it grows mainly due to imitation (q), until it reaches a maximum at the expiration of the patent T^* (see Figure 2).

The volume process is calculated by the following expression:

$$n(t) = m\left[\frac{p(p+q)^2 e^{-(p+q)(t-T)}}{(p + qe^{-(p+q)(t-T)})^2}\right] \qquad (2)$$

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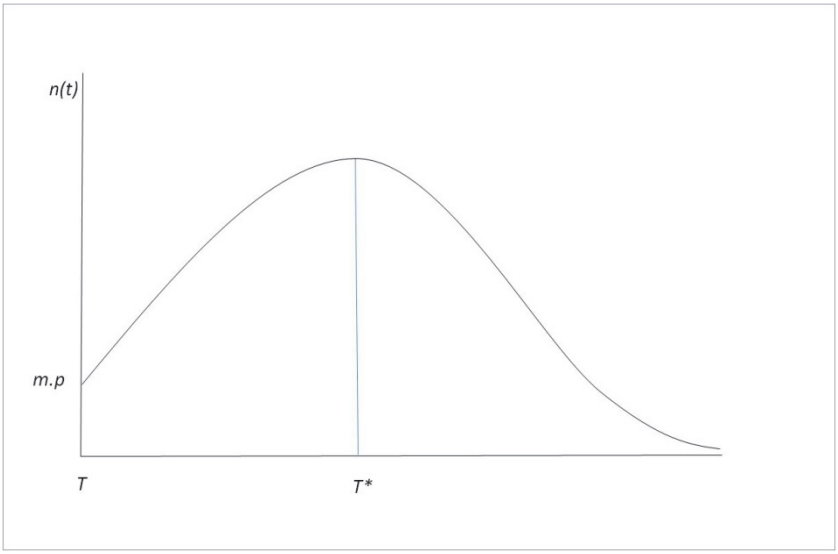

Fig. 2 Life cycle

2.2. Price process

Once the sales process is well-defined, it is essential to describe the price process. Following Shlomo Kalish (1983), the producer uses the market-skimming pricing strategy. The initial value P^M is high, supported by the monopoly power of the patent. The price of monopoly is a fixed value during the term of the patent (P^M) and has negative impact on sales, so $m'(P^M) < 0$. After its expiration, the market gradually enters in competition, so the producer is forced to reduce its price.

Once the patent expires, the market slowly enters in competition and the price begins to decline tending asymptotically to zero:

$$P(t) = \begin{cases} P^M & T < t \leq T^* \\ P^M\left(1 - e^{\xi(T^* - t)}\right) & t > T^* \end{cases}$$

2.3. Benefit process

As mentioned above, sales inversely depend on monopoly price, so the volume of sales at time t is now described by (See figure 3):

$$n(t, P^M) = m(P^M)\left[\frac{p(p+q)^2 e^{-(p+q)(t-T)}}{(p + qe^{-(p+q)(t-T)})^2}\right]$$

And the net benefit is:

$$b(t, P^M) = (P(t) - c_V) * n(t, P^M) - C_F \qquad t > T \qquad (3)$$

where

c_V: Variable cost per unit produced

C_F: Fixed cost

Final condition: $\lim_{t\to\infty} b(t, P^M) = 0$

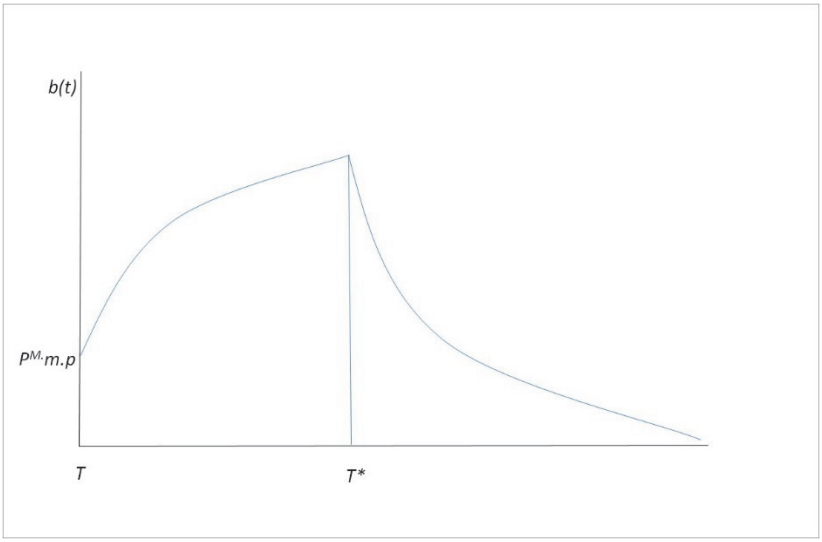

Fig. 3 Benefit process

And the net present value of the future benefit is this discounted integral:

$$VPB(T) = \int_T^{\infty} b(t, P^M).\, e^{-rt} dt \qquad (4)$$

3. The Algorithm[20]

After presenting the processes involved in the previous sections, this section develops a backward induction algorithm to calculate the value of the project at the beginning.

[20] Based on (Longstaff y Schwartz (2001) y Hsu y Schwartz (2008).

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3.1. The Abandon Option

As mentioned earlier, innovative projects are sequential and it is not necessary to give all the investment at the beginning. Before any stage, the investor compares the new contribution with the expected value of the project. If the latter is less than the former, the project is abandoned.

In other words, the decision rule is: the project continues if and only if the present value of the expected project is greater than the new contribution needed.

3.2. Simulation paths

The proposed model uses simulation, following the guidelines of Longstaff y Schwartz (2001). The procedure uses backward induction, starting at time T where the value of the project is the present value of future net profit:

$$V(t^{n+1}) = VPB(T)$$

First, M independent paths of state variables are simulated: $j = 1 \ldots M$. Each of these paths has n nodes where each first node ($i = 0$) correspond to the initial investment decision. Moreover, every successive node ($i: 0 < i < n$) involves a new investment decision. Starting from the total remaining cost $c_i(0)$, the algorithm simulates the corresponding path j, where $c_j^i(t_j^{i-1})$ is the cost in each node.

3.3. Backward Induction

For each node i (in every path j) the algorithm calculates the conditional expected value of the Project:

$$\tilde{v}(t_j^{i-1}) = E\left[V(t_j^i)\, e^{-(r+\lambda_i)(t_j^i - t_j^{i-1})} - \int_0^{(t_j^i - t_j^{i-1})} I_i\ e^{-(r+\lambda_i)t} dt\right] \qquad (5)$$

To construct the estimation of $v(t^{i-1})$, a regression of the set of values $\tilde{v}(t_j^{i-1})$ on the functional space $c_j^i(t_j^{i-1})$ is needed.

3.4. Decision to abandon

Following Hsu y Schwartz (2008) , v(t) is the present value of the Project ex-ante abandon decision, and V(t) is the value with the abandoned option included. So, the conditional expectation based on the total cost expected at the beginning of the stage is:

$$v(t^{i-1}) = E\left[V(t^i)\, e^{-(r+\lambda_i)\tau_i} - \int_0^{\tau_i} I_i\ e^{-(r+\lambda_i)t} dt \,\middle|\, c_i(t^{i-1})\right] \qquad (6)$$

Summing up, the decision rule is: Continue if and only if $\hat{v}\left(c_j^i(t_j^{i-1})\right) > 0$

3.5. Project Value

Once the decision rules are defined (continue or abandon) for each node, it is possible to evaluate the value of the R & D project. Each path is a flow of future income and expenditures that must be discounted until it reaches zero. It runs from the decision of abandonment (or from the final node), discounting until the start of the project value and subtracting the investments made to reach this node. So we have n instances of the initial value of the project, a discrete distribution. Usually, its mean represents the expected value.

4. Conclusions

This paper has developed an investment valuation model based on Real Options methodology, taking into account its features: uncertainty, flexibility and sunk costs. It modelled the cost of every stage using a stochastic learning process with different sources of uncertainty.

This is of fundamental interest to investors in the market for innovative products. In future works it would be relevant to calibrate the present model to different cases in innovative industries.

Acknowledgements

We appreciate the comments and help from María Teresa Casparri.

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The effect and management of work in entrepreneurship and open innovation

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Extended Abstract

Purpose: *From the seminal research by Burns and Stalker (1962) which highlights the necessary adjustment between the innovation strategy and the organic forms of the organizational structure up to the work by Johnson et al. (2003) which shows the close interdependence between strategy and organization, the literature emphasizes the need for forms of work organization to be simultaneously adjusted to the characteristics of the task (Perrow, 1970) and the strategic objectives of the company (Peris-Ortiz et al. 2012). These questions still conserve their entire relevance when we associate the different types of work of the company with the form of their management and with the strategies of entrepreneurship and open innovation. Accordingly in the four types of work which we use as an analysis instrument, and which we have identified in the 50 cases studies, we examine their different levels of centralization and formalization and their human resources policies which consist in providing the incentives that focus the conduct towards the fulfilment of the company objectives, when the flexibility and autonomy in the work place (conditions for cooperation in open innovation) are the required forms of organization.*

Research methodology: *This study uses qualitative comparative analysis (QCA) to analyze the different types of work and the best human resources policy that are most conducive to successful open innovation, and on the contrary, the configurations that annul this innovation. QCA assumes complex causality and focuses on asymmetric relationships to detect configurations (combinations of factors) that are minimally necessary and/or sufficient to cause a specific outcome (Woodside, 2013). Based on 17 case studies in different firms and public institutions covering the four types of work considered, this study analyzes the different combinations of human resource policies regarding the employee's promotion, remuneration, career development, formalization and autonomy in the task decision. Work*

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specialization and work group complete the variables required to explain the use and effectiveness of open innovation.

Findings and discussion: *Qualified and creative jobs as well as the autonomy, worker's delegation and decision-making capacity in the field of the task require high decentralization. These types of works are prone to entrepreneurship and open innovation, but to facilitate this, managers should implement complementary human resources policies. The results show that, as expected, the adoption of entrepreneurship and open innovation is linked to decentralized, little formalized, creative and qualified jobs and policies which call for motivation in order to favor entrepreneurship and open innovation among employees.*

Research limitations: *The study has some limitations, notably the reliability of the measurement of the variables, based on the subjective assessment of the respondent employee. The limited number of cases is always a question to be considered, although the statistical results show consistency in the results.*

Practical implications: *Finally, one of the most interesting results of this study is the poor results in entrepreneurship and open innovation obtained when the employees possess autonomy but this autonomy is not supported by an appropriate human resource policy regarding career development and promotion or other compensations. On the other hand, conformity and positive adjustment have been observed among the policies of decentralization, assignment of incentives entrepreneurship and open innovation.*

Keywords: *Entrepreneurship, human resource policy, autonomy;innovation strategy; qualitative comparative analysis.*

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EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

A century of the journal of applied psychology: A bibliometric overview

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Abstract

The Journal of Applied Psychology published its first issue in 1917. In 2017, the journal celebrates a century of publications. Due to this, the aim of this article is to develop a bibliometric analysis of the leading trends that are occurring in the journal through this time. For doing so, the study uses the Scopus database and analyses a wide range of issues including the publication and citation structure, the most productive authors, institutions and countries, and the most cited papers. Moreover, the work also develops a graphical analysis of the bibliographic material of the journal by using the visualization of similarities (VOS) viewer software. The study maps the data in terms of bibliographic coupling, co-citation, citation, co-authorship and co-occurrence of author keywords. The results show the strong influence the journal is achieving in the scientific community and the dominance of the USA in terms of authors, universities and most cited papers.

Keywords: *Bibliometrics, Scopus, citations, VOS viewer*

Full version in Business and Management Research (ISSN 1927-601X)

A bibliometric overview of innovation research: A journal analysis

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Abstract

Innovation research is becoming very significant during the last decades due to the strong development of research and technology worldwide. The aim of this study is to present the evolution of academic research in innovation between 1989 and 2013. In order to do so, this work uses the Web of Science Core Collection database, which is usually regarded as the most significant one for scientific research. The article analyzes the annual numbers of studies in innovation and compares it with the total number of articles published annually in the database. Next, the work studies the citation structure in this field in order to see the number of cites obtained by any article in the discipline. The study ends analyzing the most influential journals in this area. The article also develops a graphical visualization of the bibliographic material by using the VOS viewer software. The results show a strong increase of innovation research during the last years with many leading management journals publishing significant studies in this field.

Keywords: *Innovation; bibliometrics; journals, Web of Science, VOS viewer.*

Full version in Business and Management Research (ISSN 1927-601X)

Social Innovation in the Automotive Industry: A Case of Study

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Abstract

Interest in social innovation is growing rapidly for many reasons and there are countless examples of enterprises in various fields. This article examines the case of social innovation in the automotive industry. ILUNION Business Group as a business division of the Spanish National Foundation for the Blinds to generate stable employment for handicaped people, thanks to a philosoy of innovation this group have gron year after year. This growth is reflected in the social values of integrating people. Inside of this group is Modular Logistica Valenciana (MLV), this company is focused on warehouse management and control, including logistics services, assembly of components, repair, overhaul of parts, etc. MLV has grown to become the largest Ford logistics operator in Valencia. 95% of its employees have disabilities (70% are phisically disabled, 8% are mentally handicapped, and the remainder have sensory disabilities). In this paper we explain how this is a win-win paradigm for the company, for the employees and for the automotive industry. We examine the MLV case, this is a direct action by the company. Its actions has permanently modified a social imbalance in the employment of handicaped people. But is a sustainable social value at the same time, for this the company must remain profitable to ensure the sustainability of the jobs.

Keywords: *Social innovation; automotive industry, sustainability, handicaped people.*

Full version in Business and Management Research (ISSN 1927-601X)

EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Academic research in management: A bibliometric analysis

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Abstract

Bibliometrics is a research field that studies quantitatively the bibliographic material. It provides a wide range of techniques for representing and classifying the information of a research area. This paper studies some key bibliometric indicators regarding the most influential research carried out in management over the last decades. For each of the 30 selected journals, it is given an individual focus with the most productive institutions and countries. The results are in accordance with the common knowledge where the USA and other English speaking countries are clearly leading the field. However, some important deviations are found due to the nature of some specific research topics that may provide a ranking different from the initial expectations. Finally, it is worth noting that the results of this paper aims to be informative regarding the most influential research being developed in management. But the rankings are not strict because each research topic may have a different style in publishing research.

Keywords: *Innovation; bibliometrics; journals, Web of Science, VOS viewer.*

Full version in Business and Management Research (ISSN 1927-601X)

AMSE 2017
International Conference on Modelling and Simulation

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The AMSE association, through its International Conferences, wants to offer a forum where university people, professionals and practitioners, working in the field of modeling and simulation, can exchange ideas and experience on the advancement of research, methods, techniques, applications and projects based on Fuzzy Sets and Systems, Soft Computing, Intelligent Systems, New Quantitative Methods and Related Applications.
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