Firm, industry and corporation effects revisited: A mixed multi-level analysis for Chilean companies

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Abstract

The relative importance of the corporate, industry and firm effects on business' performance has been studied profusely in the literature. Until now, little has been said about the nested structure of the problem. The multi-level analysis appears as a good alternative over the approaches used so far to better understand this phenomenon. This paper analyzes the significance of the aforesaid effects for Chilean firms and assesses the impact of various regressors on residual variances. Export intensity of firms and industries proved to have a significant impact on the estimated industry effect, making the industry-related variance statistically not different from zero. However, the industry's influence did not totally disappear, because the effect of export intensity on firms' profitability depends on the industry to which the firm belongs. Moreover, firm size turns out to be significant and positively associated to firm´s return, which can be evidence of economies of scale or more efficient processes as a company grows in size.

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I .Introduction

The factors behind firms' profitability have long been a subject of study in economics and strategic management. In the last several years, a great part of the research has focused on quantifying the impact of the corporate effect, the industry effect and the business-unit effect on the variability of firms' profitability (Schmalensee, 1985; Rumelt, 1991; Roquebert et al, 1996; McGahan & Porter, 1997 and 2005; and Hawawini *et al.*, 2003). The two most common methods to estimate the importance of business units, industries and corporations on firm´s profitability were the ANOVA methodology and the variance components analysis.

The ANOVA methodology involves the use of dummy variables for each category of effects being measured. These categories are incorporated in a pre-established order, and the importance of each one is calculated through the change in R^2 resulting from the inclusion of that specific variable. Rumelt (1991) and others have showed that ANOVA estimation of the different effects showed great variation in the results as the order in which the dummy variables were added to the model. On the other hand, the variance components methodology seeks to decompose the total variance of the dependent variable into the sources defined by the researcher. Brush & Bromiley (1997) were one of the firsts to criticize the use of variance components, because the estimates could be highly non-linear. Additionally, these authors questioned the way the corporate effect was input in the specification proposed by Rumelt (1991), because it assumed that the corporate effect influenced every business alike. These critics became an incentive to search for new approaches. One example was McGahan & Porter (2002), proposing the use of a simultaneous ANOVA model that, unlike previous ANOVA analyses, takes into account the existence of covariance between industry and corporate effects.

Hough's (2006) proposed that the multi-level analysis is a better methodology than those used until then to compute firm, industry and corporate effects since it allows to model the relationships among the different levels of data using categorical or continual variables, while admitting complex structures for the residual terms. Multi-level analysis, widely used in social sciences, takes into consideration the hierarchy prevailing on these effects: there are business units, which compete or group into industries and, at the same time, create corporations. As such, multi-level analysis may reveal that the units belonging to a group are more similar to each other than they are to units of other groups. This represents a methodological advance, because it allows to separate the total variance of the variable under study into its various components (associated to the respective hierarchy) and subsequently, the possibility of using fixed-effect variables to identify the drivers of the variances associated to each specific level.

In this paper we apply the multi-level analyses to an extensive database of Chilean companies, and compute the results for the business, industry and corporate effects for this panel. Our results show that the business effect dominates the other two, with nearly 46% of the total variance of the returns. The corporate effect follows with close to 14%, and then the industry effect with 10%. In addition to the multi-level analysis of random effects, a mixed multi-level analysis was fitted (incorporating random and fixed effects) to see the impact of certain variables on the estimates of residual variances. Export intensity of firms and industries proved to have a significant impact on the estimated industry effect. However, the industry's influence did not totally disappear, because the effect of export intensity on firms' profitability depends on the industry to which the firm belongs. Moreover, firm size turns out to be significant and positively associated to firm´s return.

II. Variables, data source and filters used in this study

The dependent variable is return on assets. It is defined as operating result at the end of December of any given year over total identifiable assets at the end of December of the year before, where identifiable assets are defined as total assets minus investments in related firms and investment in other companies. Multiple papers use this measure of profitability (for example, Rumelt, 1991; Roquebert *et al.,* 1996; Ruefli *et al.,* 2003). Hawawini *et al.* (2003) tested the importance of the firm and industry effects using different indicators of economic performance and returns on assets, finding that the relative importance of the effects was not altered by the definition of economic performance. Based on our literature review, the following independent variables were considered:

Total identifiable assets. It is used as an estimate of firm size, using a logarithmic transformation of exponential base. Majumdar (1997) claims that the theory is equivocal in the predictable relationship between size and performance since on the one hand, "large" firms would be capable of exploiting economies of scale and scope by boosting performance and, on the other, their size would be associated to the development of inefficiencies-X, lowering performance. His finding for Indian firms indicate a positive relationship between size and profitability, as measured by margin over sales. In other studies Misangyi *et al.* (2006) include the business segment size as a control variable, finding a positive relationship between it and its own returns on assets while Yasuda (2005) finds a negative relationship between firm size and firm growth.

Age. The age of each firm was computed as the difference between the year for which information is gathered and the firm's year of incorporation plus one. As with size, the theory does not provide an unambiguous answer regarding he relationship between age and performance. On one hand, there is the argument that with age comes expertise, positively affecting profitability. Conversely, age is also linked to red tape and lack of flexibility to adapt to changes. Most of the empirical studies (Majumdar, 1997; Durand & Coeurderoy 2001; Yasuda, 2005 and Chakrabarti *et al.*, 2007) find that age has a negative effect on performance.

Exports/operating income. It was calculated as the ratio of firm's total exports over the firm's total sales for each year. Its inclusion in the study responds to the attempt to finding some measure of the firms' exposure to international trade. The work by Majumdar (1997), posits that there is no theory delivering, a priori, an expected relationship between this variable and firm's performance.

Current ratio. It corresponds to the ratio of current assets over current liabilities. It has been used as a control variable to proxy for the constraint on the available resources in an organization (e.g., Majumdar, 1997; Chakrabarti *et al.,* 2007). In the case of Majumdar (1997), this variable has a negative impact on the profitability of Indian firms, while in Chakrabarti (2007) is positively related with the sample's returns on assets. However, in both cases the estimated coefficients are not statistically significant at the 95% confidence level.

The main source for the data is Economatica. This is an extensive data base of financial information on firms from several Latin American countries and the U.S. It provides accounting information and industry classification based on the North American Industrial Classification System (NAICS). The information regarding exports was gathered from ProChile, a government agency that provides information on international trade figures for companies based on Chile. Finally, data from the Superintendency of Securities and Insurance (SVS) was gathered to estimate the age of companies and their belonging to an economic group. The data provided by Economatica for the period 1998-2007 for Chilean companies covers 2,127 observations of returns on assets, corresponding to 302 firms.

Following the literature (see, for example, Roquebert *et al.*, 1996; McGahan & Porter, 1997 and 2002; Khanna & Rivkin 2001; Hough, 2006, Galbreath & Galvin, 2008), we applied different filters to our database, such as elimination of firms related to the financial sector; elimination of firms not having an industry classification at the second level of disaggregation or classified under “other industries”, elimination of observations from firms with identifiable assets amounted to less than US$500.000, elimination of the top and bottom 2.5% of returns on assets observations and elimination of observations not containing information for all the independent variables considered. Table 1 summarizes the final data used in our study.

Table 1 here

We used Iterative Generalized Least Squares (IGLS). This algorithm first estimates the fixed part of the model from a “reasonable” estimate, which could be the one we would obtain if we used ordinary least squares. Then, the so-called “unprocessed residuals” are processed, which are the difference between the observed value of the dependent variable and the estimators for the fixed part. With these, a regression by generalized least squares is run, which permits to estimate the random parameters. The results obtained are used for a new iterative process, which is repeated over and over until the estimates do not change from one cycle to the next. IGLS leads to an estimation that is equivalent to that for maximum likelihood, so models are compared using the change in the *deviance.*[1]

III. Results for the multi-level model of random effects and ANOVA

Initially, a multi-level model of random effects was fitted to obtain an estimate of what portion of the total variance of the returns corresponds to each one of the levels being studied for the sample of Chilean firms. The dependent variable is measured in percentage. The fitted model is:

$$Y_{ij(kl)} = a + u_l + v_k + w_{j(kl)} + e_{ij(kl)}$$

where the returns on identifiable assets in period i of firm j belonging to industry k and corporation l, are broken down into a constant a, plus the sum of the corporate (u_l), industry (v_k), and firm ($w_{j(kl)}$) effects and the error term ($e_{ij(kl)}$). Said effects are assumed to come from normal distributions with zero mean and unknown variance. Subscripts k and l are in parentheses to denote the cross classification between the higher levels (corporation and industry). The results are shown below:

Table 2 here

The results indicate that the most important level is the firm, which concentrates nearly 45% of the total variance of the returns, followed by corporation (14%) and industry (11%). Though the variance estimate from the corporate and industrial levels may seem non-significant, the significance of the random parameters must be checked with the change in the model's *deviance* and not just using the Wald test (because the distribution of the

[1] The *deviance* is understood as minus twice the logarithm of the model's likelihood. The higher the *deviance*, the worse the model. The significance of changes in the *deviance* is tested using a Chi-squared distribution.

variance estimators is only approximately normal, Rasbash *et al.(*2009)). Applying the test based on deviance, both the industry and corporate effect are significant.

We should notice that when comparing the results obtained with a multi-level model with those of ANOVA, there is an important difference in the impact of the industry effect: while our ANOVA analysis with the same database yields an industry effect between 19,5% and 23% (depending on the order of entry of this effect) the multi-level analysis results in an industry effect of 10,51%. One reason behind these differences could be that ANOVA does not consider the problem's nested structure, ignoring that firms belonging to the same industry have more in common that those in different industries. This lack of independence of the units studied, jointly with a specification that is not identical, may be explaining the differences in the estimations.

IV. Results for the mixed multi-level model

One of the main advantages of the multi-level analysis is the possibility of including explanatory variables in the random effects model to identify the drivers of the effects analyzed. Initially, a multi-level model with fixed effects was fitted for the variables age, export-intensity, current ratio and size, and random effects for each of the hierarchical levels considered (corporation, industry, firm and error). The model proposed and its results are shown below:

Model 1

$$Y_{ij(kl)} = a + b_1 Age_{ij(kl)} + b_2 Export\_intensity_{ij(kl)} + b_3 Current\_ratio_{ij(kl)} + b_4 Size_{ij(kl)} + u_l + v_k + w_{j(kl)} + e_{ij(kl)}$$

Table 3 here

From table 3 we conclude that only firm size turns out to be significant, which can be evidence of economies of scale or more efficient processes as a company grows in size. The above results are derived from one of the simpler multi-level models, as it incorporates only fixed effects for the explanatory variables of interest. However, we want to test for the presence of other forms of influence by the corporation, industry and firm levels, which calls for an in-depth analysis of each one of the explanatory variables. To perform this, aggregations were tested for each variable at higher levels. Additionally, we add as independent variables an export dummy and the average intensity industry´s export. The export dummy captures part of the firm's exporting dimension, indicating the presence of the firm in either the exporting or not exporting category, while the average industry's export intensity in period *i* is intended to reveal part of the competitive environment by estimating what proportion of the firms' income originates, on average, in sales to external markets. A high export intensity rate for a given industry would indicate that, on average, a majority of firms in that industry are capable of exporting and selling their goods abroad. This exporting capacity, combined with their higher expected survival probability (Bernard & Jensen, 1999), may spurs rivalry within the industry. The model that provides the best fit was:

Model 2

$$Y_{ij(kl)} = a + b_1Age_{ij(kl)} + b_2Export\_intensity_{ij(kl)} + b_3Current\_ratio_{ij(kl)} + b_4Size_{ij(kl)} + b_5Export\_dummy_{ij(kl)} + b_6Avg\_industry's\_export\_intensity_{ik} + u_l + v_k + w_{j(kl)} + e_{ij(kl)}$$

Table 4 here

The newly added variables present great statistical significance (both are significant at the 99% confidence level). Next, we check the existence of random slopes for some of the hierarchical levels presented, since this could be evidence of other type of influence of the levels considered. According to Snijders & Bosker (1999), in a multi-level model it is generally common that the algorithm used for estimation would not converge for more than two or three variables with random slopes. Below is the model with the random terms for which the algorithm did converge best and turned out to be significant:

Model 3

$$Y_{ij(kl)} = a + b_1 Age_{ij(kl)} + (b_2 + v_{1k}) Export\_intensity_{ij(kl)} + b_3 Current\_ratio_{ij(kl)} + b_4 Size_{ij(kl)} + (b_5 + v_{2k}) Export\_dummy_{ij(kl)} + b_6 Avg\_industry's\_export\_intensity_{ik} + u_l + v_{ok} + w_{j(kl)} + e_{ij(kl)}$$

Table 5 here

The variance components of the intercept changes if we compare them with those in model 2. One way to estimate the change in the explained level-1 variance (considering the inclusion of random slopes into some coefficients) is to evaluate the change in the variance of the intercept (Snijders & Bosker, 1999). In this case, including the new random terms increases the explained variance of the model's level 1, which helps us to rule out the presence of a misspecification of the model.

As for the estimated fixed effects coefficients, the most notorious change has to do with the export intensity variable, since it becomes statistically different from zero at the 90% confidence level. This significance sheds new light in that export intensity measures a different dimension from that of the export dummy variable. A firm's exporting capacity, measured by the fact that it is capable of exporting within a specified period of time, or by how much of its total operating income comes from sales overseas, is positively related with its operating performance.

The variance of the intercept associated with the industry level becomes not different from zero when the corresponding deviance test is performed. This latter result indicates that the entire industry effect estimated initially (that corresponds to the random effects model at the beginning of the section) disappears after controlling for the fixed effect variables included. Thus, the impact of the industry level on the firm's returns is uneven: the existence of a significant variance for the export-intensity coefficient and the export dummy indicate that the impact of the firms' exporting dimension differs across industries.

VI. Conclusions

The advantages of the multi-level analysis over the ANOVA were presented using the case of Chilean firms, where the variance of the returns on identifiable assets was split into the sum of the variances of the corporation, industry, business unit and year (or error term). In the multi-level analysis, the industry level was the one with the smallest variance, with little over 11% of the total. The corporate level comes second with close to 14%, while the firm level concentrates 46% of the total variation of the returns. Results for ANOVA with the same database show much larger industry effects.

The literature (see, for example, Galbreath & Galvin, 2008) has underscored the importance of knowing the drivers of the different effects, that is, what ultimately causes an impact on the performance of the different business units. This objective is what incentives the use of various explanatory variables capable of reducing the estimated variances associated with the recognized hierarchical levels. Among our choice of regressors, the firm's export intensity (and the industry's within a specified period of time) ended up being very important. Even if industries differ in the export intensity of their member firms, the impact of this variable is not the same across all industries, thus triggering a new industry effect. Accordingly, the impact that any level may cause on the dependent variable under study is not restricted exclusively to a variance in the intercept, but also in the estimated fixed effects coefficient.

Most of the latest works in this area share the idea that the firm-specific resources and capabilities explain, to the largest extent, the differences in performance from one firm to another. Keeping this in mind, the next rung in the research ladder is to find the variables that explain those differences. Here, several explanatory variables were included (size, age, current ratio and export intensity of each of the firms), but the firm-level variance remained almost fixed.

Table 1
Descriptive Statistics

Period 1998-2007	**Chile**
N° of Corporations	136
N° of Industries	42
N° of Firms	218
Nº of observations	1,564
Average RIA	4.99%
Minimum RIA	-24.97%
Maximum RIA	26.77%
RIA Standard Deviation	8.92%

Table 2
Results for a multi level analysis of random effects

Fixed effects	Coefficient	S.E.	
Intercept	3.528 *	0.821	
Random effects	Variance	S.E.	% Variance explained
Corporation	12.306 *	6.716	14.33
Industry	9.029 *	4.963	10.51
Firm	39.722 *	6.656	46.25
Error	24.822 *	0.956	28.90
Deviance	10,045,290		
Nº of observations	1,564		

* Significant at the 99% confidence level.

Table 3
Results for model 1

Fixed effects	**Coefficient**	**S.E.**
Intercept	-13.148 *	2.513
Age	-0.022	0.017
Export intensity	1.577	1.399
Current ratio	0.001	0.002
Size	1.570 *	0.212
Random effects	**Variance**	**S.E.**

Corporation	8.292 ‡	5.636
Industry	7.131 ‡	4.175
Firm	38.005 *	6.149
Error	24.079 *	0.928

Deviance	9,981.798	
Nº of observations	1,564	

* Significant at the 99% confidence level.

‡ Significant at the 95% confidence level

Table 4
Results for model 2

Fixed effects	**Coefficient**	**S.E.**
Intercept	-11.009 *	2.521
Age	-0.022	0.017
Export intensity	2.887	1.771
Current ratio	0.001	0.002
Size	1.372 *	0.215
Export dummy	1.889 *	0.533
Avg. industry's export intensity	-8.786 *	2.897
Random effects	**Variance**	**S.E.**
Corporation	8.693 ‡	5.605
Industry	6.429 ‡	3.936
Firm	36.646 *	5.977
Error	23.792 *	0.917

Deviance	9,959.615	
Nº of observations	1,564	

* Significant at the 99% confidence level.

‡ Significant at the 95% confidence level

Table 5
Results for model 3

Fixed effects	**Coefficient**	**S.E.**
Intercept	-11.897 *	2.520
Age	-0.027	0.017
Export intensity	5.448 †	2.799
Current ratio	0.001	0.002
Size	1.439 *	0.216
Export dummy	2.316 *	0.717
Avg. industry's export intensity	-9.310 *	3.071
Random effects	**Variance**	**S.E.**

Corporation	10.215 *	6.034
Industry	3.133	3.209
Export int. slope variance	51.548 *	33.774
Export dummy slope variance	3.932 ‡	2.977
Firm	38.045 *	6.266
Error	22.961 *	0.892

Deviance	9,941.003
Nº of observations	1,564

* Significant at the 99% confidence level.
‡ Significant at the 95% confidence level
† Significant at the 90% confidence level.

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