# UNDERSTANDING THE RELATIVE INFLUENCE OF SEVERAL FACTORS ON ERP SIMULATION PERFORMANCE: AN EXPLORATION OF ECOLOGICAL VALIDITY

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## ABSTRACT

*This study evaluates the relative factors that influence business simulation game outcomes through exploring ecological validity. A regression model analysis was conducted to access the impact of real-world industry factors that influence performance outcomes in a business simulation game. The factors represent a composite of typical company industry measures to evaluate profitability. The study extends beyond prior literature performance outcome measures of return on investment (ROI), and return on assets (ROA) to evaluate business simulation performance. The results showed that 77% of the variance associated with performance outcome is explained by this study's independent variables. The implications for this study is the first of a two-part research effort to examine the question of whether the ERP business simulation game, ERPSim exhibits natural market structures. The part one study provides the basis to understand the factors that influence profitability in the simulation game. These results lay the ground work to complete the ecological validation of the ERPSim. The findings strongly indicate important real-world factors to predict profitability outcomes in the ERPSim business simulation game. Thus, providing evidence to compare business simulation market share and profitability levels between ERPSim and PIMS (Profit Impact of Marketing Strategies) manufacturing industry project data for ecological validity.*

## INTRODUCTION

Business simulations used within a college or university course play an important role in exposing students to real-world business issues, decision making, and business concepts. It is vital for students to learn about business simulations as early as possible, as they will be most likely employed by large corporate enterprises performing in a similar capacity of the game environment (Winkelmann & Matzner, 2009) ( Fedorowicz, Gelinas, Usoff, & Hachey, 2004). Winkelmann et al., (2009) points out that companies stand to benefit from the appropriate specialized business knowledge and skills obtained by the student-turned-employee when making investment decisions concerning adoption, upgrade, or modifications to their existing systems. Additionally, many business simulation games are where students develop high-order reasoning and decision-making skills learning by doing (Hackney, McMaster, & Harris, 2003; Léger, 2006).

Business simulation games provide a dynamic environment for competition in business-like situations that invite participants to analyze, synthesize, evaluate and apply knowledge to compete successfully (Gosen & Washbush, 2004). By analyzing teams' performance in business simulation games, one can gain insight into the relative factors that influence outcomes that can be applied to further understand how well the simulation game represents real-world business practice. The use of teams in the business game experience has become an accepted prerequisite for high-level learning and performance (Wolfe & Box, 1987).

Business simulation games are a type of experiential pedagogy that has undertaken a wide variety of learning environments that result an increase in skills (Boyatzis & Kolb, 1991). In fact, Garris, Ahlers, & Driskell (2002) regard business simulation games as a method that epitomizes experiential learning (Anderson & Lawton, 1988; Faria & Wellington, 2005; Ruben, 1977). In the microworlds created by business simulations, students can better understand the dynamic business strategy, interactive market competition, and complex business integration (Romme, 2003). However, Lee, Koh, Yen, & Tang (2002) has argued that many technology pedagogical methods do not adequately prepare students to understand and cope with the ambiguities they will without doubt face in their chosen industry. ERPSim is the business simulation game artifact in this study and is a relatively new business simulation game. ERPSim was introduced in 2006 and developed by faculty at HEC Montreal University, based on the major industry ERP software application, SAP. The business simulation game uses the SAP ERP platform to demonstrate a supply chain organization business processes, transactions, and management decision making in the context of a manufacturing entity.

It is an ongoing effort of researchers to examine how realistic are business simulation games. This study examines the ecological validity for an ERP business simulation game. Ecological validity is defined as "the process of assessing that the conclusions reached from a simulation are similar to those reached in the real-world system being modeled" (Feinstein & Cannon, 2002, p. 427). It is impor-

tant when examining ecological validity in a research study to possess materials and setting to approximate the real-life situation that is under investigation (Goodyear & Ellis, 2008).

Ecological validity offers a closer examination of the real-world business phenomenon than internal and external validity and is often confused with external validity which deals with the ability of a study's results to generalize (Brewer, 2000; Goodyear et al., 2008). Though these validation forms are closely related, they are independent whereas a study may possess external validity but not ecological validity, and vice-versa. Brewers' (2000) research provides distinction and contrast to explain that an effect holds up across a wide variety of people or a setting is somewhat different than asking whether the effect is representative to what happens in everyday life which is the essence of ecological validity. The researcher's example, a mock-jury study shows how people might act if they were jurors during a trial, where many mock-jury studies simply provide written transcripts or summaries of trials, and do so in classroom or office settings. Such experiments do not approximate the actual look, feel, and procedure of a real courtroom trial, and therefore lack ecological validity. However, more importantly is the concern of external validity whether the results from such mock-jury studies generalize to real trials, and then the research is valid as a whole, despite its ecological shortcomings. Nonetheless, improving the ecological validity of an experiment typically improves the external validity as well. The research gives support that ecological validity is crucial for research that is undertaken for descriptive or demonstration purposes.

Therefore, this exploratory research is the basis to further understand relative factors that influence performance outcomes in an enterprise business simulation where a real-world ERP system is utilized in preparation to examine the business simulation natural market structures and scenarios to enhance learning. This research is the first in a two-part study to leverage the research of Wellington and Windor (2006). The goal of the part one research study is to understand the ERPSim profitability structure to the most current PIMS analyzing its real-world competitive market shares and rankings.

## THE ENTERPRISE BUSINESS SIMULATION

The enterprise business simulation game examined in this research study is ERPSim known as mySAP. ERPSim utilizes an innovative learning by doing approach for teaching Enterprise Resource Planning (ERP) concepts (Léger, 2006). ERPSim is a multifaceted business simulation game designed using the SAP system foundation. SAP systems are one of the world's largest inter-enterprise software applications developed and sold by the fourth-largest independent software supplier. The ERPSim captures performance activity tracked by operational, reporting, decision, and accounting transactions. The performance activity is highly realistic and meant to simulate the total business enterprise environment. Students form teams and take on individual roles similar to those in a traditional corporation such as production controller, financial manager, sales manager, and warehouse logistics personnel.

Each team operates within a made-to-stock manufacturing supply chain interacting with customer demand, product delivery, materials request planning, and the whole cash to cash cycle )Léger, 2006) . Using standard reports and the business intelligence component of the ERP, teams analyze transactions and make business decisions to ensure the profitability of their operations. Within each business quarter, teams make two important key business decisions for the market segment they wish to target. The teams develop a pricing strategy and allocate marketing expenses. The teams operate a plant involved in manufacturing and distribution of muesli cereals. Each teams' company has six muesli cereals to produce and sell.

## ENTERPRISE SIMULATION GAME PERFORMANCE OUTCOMES

One of the more common research topics in the use of business simulations has been an effort to determine factors that correlate with simulation performance. Most business simulation research has concentrated on the learning outcomes (Nulden & Scheepers, 2002), team dynamics (Wolfe et al., 1987; Anderson & Lawton, 2005) and pedagogical methods (Léger, 2006; Draijer & Schenk, 2004).

Despite the widespread use of business simulation games, the ongoing issue of concern is whether the games are a meaningful experience. Prior literature has viewed validity of business simulations as a measure of how well business games model the real-world industry within the simulation execution (Carvalho, 1991). Wellington & Faria (2006) identified two approaches that were successful for external validation of business simulation games. The approaches focused on the correlation between a business executive's simulation game performance and his or her real-world performance and a longitudinal research design where a student's business game performance is compared to a business career success (e.g., number of promotions, salary level, etc.). Also two additional studies confirm the same findings (Wolfe & Roberts, 1986; Wolfe & Roberts, 1993). Yet, few studies have empirically examined the degree to which simulated companies behave like real ones (Mehrez, Reichel, & Olami, 1987; House & Napier, 1988; Feinstein & Cannon, 2002). Therefore, it is important to understand the degree to which a business simulation game behaves in ways that are similar to the organization and markets they represent.

There is no consensus on what should or could be used as success criteria when evaluating the results of a business simulation game. House & Napier (1988) used profit driven measures of net income, return-on investment (ROI) and

return-on-assets (ROA) as the best indicators of financial performance on a business simulation exercise. Chien-Ta Bruce, Desheng Dash, & Olson (2009) conclude ROE is a more comprehensive and a better indicator than ROA or ROI in terms of a firm's profitability and potential growth and risk. Though Anderson and Lawton (1992) did not address evaluating performance in terms of profit measures, they initiated a call to action to examine the possibility of using prediction method results as a measure of business simulation game performance.

# METHOD

## SAMPLE

The sample data was collected from an experiment using ERPSim at a university in Italy. Twenty-one MBA students participated in the study divided in six teams of three or four persons. They were asked to participate in a business simulation and responded to several questions before, during and after the simulation. The data for the analysis uses only transaction data extracted from the ERPSim game execution.

## PROCEDURE

The ERPSim placed the teams in command of a muesli manufacturing company selling its products to three types of customers: hypermarket, supermarket and retailers. Team members discussed their simulation game strategy, chose which products to make and produce first, order raw material, produce muesli boxes and decide pricing and marketing strategy. The teams compete against each other on the same market in order to achieve the largest profit over the period.

For this study, all participants had already experienced the simulation. However, confirmed before the start of the simulation; the teams were composed of individuals who had not participated in previous simulations together (as a team). Teams played the simulation over two periods of 30 minutes, alone on the market, competing against the computer managing the automated demand. The experiment was divided into three phases.

**Phase 1.** Participation is performed in front of his or her computer. Teammates cannot see each other, are separated by partitions, and cannot talk to each other as they are wearing anti-noise ear covers. They were asked to answer a survey about their experience working with the Enterprise Resource Planning (ERP) system, data analysis (business intelligence), and their teammates and to determine their psychological profile according the Big Five survey. Finally participants are given their SAP account, to operate their virtual company, and Skype account to enable communication with each other.

**Phase 2.** Participants had fifteen minutes to discuss the strategy they would carry out during the first thirty minute period of the business simulation and prepare the system. The simulator was launched. Researchers only intervene during the period to resolve bugs and the simulator was never stopped. At the end of the thirty minutes, participants were asked to answer a second survey about their flow and their situation awareness over the period they just played.

**Phase 3.** After answering the surveys, participants are given five minutes to discuss the corrections and adjustments to their strategy and prepare the system for a second period of the business simulation. They start the second period with their company and the market in the same state at the end of the first period. The simulator was launched. At the completion of the simulation, researchers extract usage and business intelligence data from ERPSim, which is imported into a Microsoft Access database.

## MEASURES

The variables used in this study are measures typical of industry companies to assess company performance and profitability. This study examined not only measures of return on equity (ROE) and return on assets (ROA) from prior literature (Anderson et al., 1992; Peach, 1997), but other industry measures having an effect on profitability. The additional variables measured are cumulative net profit, marketing/sales ratio, days sales outstanding, raw material (RM) inventory days, return on sales, mean distribution center price, gross margin, and leverage. Cumulative net profit represents a company's bottom line revenue. Cumulative net profit is calculated by subtracting a company's total expenses from total revenue, thus showing what the company has earned (or lost) in a given period of time (usually one year). The marketing/sales ratio is a control measure used to determine whether the cost of the marketing activities engaged in to produce the level of sales in a given period was excessive. The ratio evaluates the total marketing expenses expressed as a percentage of total sales revenue. Days sales outstanding (DSO) is the number of days it takes to collect receivables in a given amount of time. It is an important financial indicator as it shows both the age of a company's accounts receivable and the average time it takes to turn those receivables into cash. DSO reveals how many days' worth of sales are outstanding and unpaid within a specific period. RM inventory days is a ratio to indicate how many days on average a company turns its raw material inventory into finished products. The ratio is calculated as the raw material inventory divided by consumption of raw material * 365. This measure indicates how efficient raw materials are used to produce a company's finished goods.

The return on sales (ROS) ratio is widely used to evaluate a company's operational efficiency. ROS is also known as a firm's operating profit margin. This measure is helpful to a company's management, providing insight into how much profit is being produced per dollar of sales. The mean distribution price represents the average price of

products across each of the distribution channels. Gross margin is measured as the percentage by which profits exceed production costs. It is a measure of how well a company controls its costs. The calculation for gross margin is a company's profit divided by its revenues and expressing the result as a percentage. Leverage also referenced as the debt-to-equity ratio, which shows how much of the assets of the company are financed by debt and how much by equity (ownership). Leverage is useful for a company to fund growth and development through the purchase of assets. If a company has too much outstanding liability, it may not be able to pay back all of its debts.

## RESULTS

**Model 1.** An exploratory multiple linear regression model was developed to account for variability in cumulative net profit. Predictor variables included return of assets *(ROA), return on equity (ROE), mean distribution center price, gross margin and marketing*. Regression analyses were conducted using SAS 4.2 Enterprise Miner. The analysis showed that variable "marketing" was excluded from the model due to a lack of variability among the data points (the majority of data points (75%) were zero values, while the remaining entries included only nine numbers: 100, 500, 1000, 1200, 1500, 2000, 3000, 4000, 5000). The system thus treated it as a constant and it was not included into the prediction equation.

Next, variables ROA and ROE showed problems with multiple collinearity (tolerance values < .10 and VIF > 10). Further inspection of their bivariate correlations with the criterion (i.e. cumulative net profit) indicated perfect relationships with the dependent variable (r=1.00). This is not surprising as these variables were probably derived using cumulative net profit values in the numerator of the formula for both ROA and ROE.

Variables 'gross margin' and 'mean distribution center price' were retained in the model and together accounted for 13% of the variance in the cumulative net profit ($R^2$ = .14), which was statistically significant ($p<0.05$). Independently each of the variables was a significant predictor of the cumulative net profit with 'gross margin' providing the greatest contribution to the equation (standardized beta = -.343). The relationship with the DV was negative, with a smaller gross margin associated with a larger cumulative net profit.

**Model 2.** Since 'gross margin' and 'mean distribution center price' could only account for 14% of variability in the dependent variable, I attempted to identify other variables that may improve the predictive power of the model. First, all remaining numeric variables were simultaneously entered in the equation to identify predictive redundancies (multiple collinearity). This strategy yielded problems with multiple collinearity for the following variables: *equity, current asset turnover, leverage, debt/equity, current ratio, plant asset turnover, and cumulative sales.* Bivariate correlations showed that all of variables were significantly correlated with each other and with the cumulative net profit. Equity showed a perfect correlation (r=1.00) with the DV and was thus excluded from further analysis. Leverage had the second highest correlation with the criterion (r = -0.766, $p<0.01$) and was thus selected for inclusion into the final model. The remainder of the variables *Mktg/Sales, SalesDaysOutstanding, RMInventoryDaysOutstanding, and ReturnOnSales,* did not show problems with multiple collinearity and together accounted for 64% of variability in the cumulative net profit (adjusted $R^2$ = 0.642), which was statistically significant.

**Final model.** Next I attempted to improve the predictive power of the final model by combining viable variables from the previous two models. Thus the final model included seven unique (non-redundant) predictors: *mean distribution center price, gross margin, leverage, Mktg/Sales, SalesDaysOutstanding RMInventoryDaysOutstanding, and ReturnOnSale.* The results of the final regression analysis showed that the model has improved its predictive power to 77%, which was highly significant, ($R^2$ = 0.766, $F$ (7,309) = 144.58, $p$ = .000). None of the final eight variables showed problems with multiple collinearity. Table 1 presents the descriptive statistics and correlation matrix of all

**Table 1**
**Descriptive Statistics and Correlations**

| Variable | M | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. CumulativeNetProft | -6.77 | 2.56 | | | | | | | | |
| 2. Mktg/Sales | 0.14 | 0.10 | -0.39 | | | | | | | |
| 3. SalesDaysOutstanding | 18.21 | 4.11 | -0.16 | 0.22 | | | | | | |
| 4. RMInventoryDaysOutsanding | 18.41 | 14.56 | 0.58 | -0.13 | -0.17 | | | | | |
| 5. ReturnOnSales | -0.28 | 0.61 | 0.39 | -0.39 | 0.47 | -0.12 | | | | |
| 6. MeanDCPrice | 4.62 | 1.28 | 0.13 | -0.25 | -0.03* | '0.04* | 0.18 | | | |
| 7. GrossMargin | -0.51 | 0.23 | -0.35 | 0.17 | 0.18 | -0.12 | -0.24 | -0.01* | | |
| 8. Leverage | 2.15 | 0.07 | -0.78 | 0.26 | -0.06* | -0.67 | -0.30* | -0.00* | 0.20 | |

Note: Correlations in Rows 1 through 8 (n=317) with an absolute value of .05 or greater is statistically significant at $p < .05$.

variables in the final analysis. Six independent variables had correlations with performance at the .05 significance level.

Statistically significant individual contributions were observed for 'SalesDaysOutstanding' (standardized beta = -0.342; $p < 0.01$), 'RMInventoryDaysOutstanding' (standardized beta = 0.194; $p<0.01$), 'ReturnOnSales' (standardized beta = 0.399; $p<0.01$), and 'leverage' (standardized beta = -0.551; $p<0.01$). As can be deduced from the standardized beta values the most significant predictor in the model was 'leverage' followed by 'ReturnOnSales". While greater values of the latter variable were associated with greater cumulative net profit, smaller leverage values were associated with higher values of the cumulative net profit. Table 2 summarizes the results of the regression modeling.

## DISCUSSION AND CONCLUSION

This research study is the first to approach the ecological validity of the ERPSim business simulation game. The intention of this study was to ascertain the relative influence of a myriad of variables on performance in an enterprise business simulation game. The study attempted to discriminate between those variables that significantly affected performance and those whose influence was superfluous in order to capture the real-world business environment and its impact on simulated game profitability. These findings eliminate the common-method variance to explain true variance due to the data collection method. The data collection approach for the study captured real-time actual transaction usage data rather than self-report from a questionnaire. Therefore, the data collection approach ameliorates the effect of common-method variance.

The results of this regression analysis showed that the independent variables in the study explained 77% of the variance of performance in the simulation. This is a significant contribution over prior literature results of 44% to explain profit outcomes in a business simulation game. Thus, it can be concluded that these factors associated with real-world business measures did in fact significantly influence performance outcomes providing support for the business simulation game outcome profitability. These findings provide the confirmation to support part two of the ecological validation.

The study has a few limitations noted that can be addressed in future studies. The results can be replicated in perhaps other cultural contexts for differentiation in results. Individual learning styles, decision-making, and business acumen may vary from country to country. The sample used in this research study is limited to participants from the country of Italy.

Learning an enterprise resource planning system is typically time and resource consuming, and is a great frustration on the part of faculty and students alike to grasp understanding. However, when successful, the effort greatly improves the content and pedagogy of business education. Students gain a better understanding of the real-world business processes, company roles and responsibilities, and business strategy skills that has immediate benefit for their initial jobs.

Additionally, due to SAP's wide exposure across industry companies, students who have participated in ERPSim are more favorable to potential employers. Companies gain entry level employees with considerable enterprise

**Table 2**
**Results of Regression Modeling: CumulativeNetProfit as Dependent Variable**

| Variable | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | β | ρ | β | ρ | β | ρ |
| Constant | | 2160 | | -3.83 | | 4.6 |
| CumulativeNetProft | - | - | - | - | - | - |
| Mktg/Sales | - | - | - | - | 0.31 | 0.38 |
| DaysSalesOutstanding | - | - | - | - | -0.34 | 0.00 |
| RMInventoryDaysOutsanding | - | - | - | - | 0.20 | 0.00 |
| ReturnOnSales | - | - | - | - | 0.40 | 0.00 |
| MeanDCPrice | 0.00 | 0.70 | 0.128 | 0.02 | 0.05 | 0.10 |
| GrossMargin | 0.00 | 0.24 | -0.343 | 0.00 | -0.06 | 0.06 |
| Leverage | - | - | - | - | -0.55 | 0.00 |
| ROA | 1.79 | 0.00 | - | - | - | - |
| ROE | -0.78 | 0.00 | - | - | - | - |
| $R^2$ | 1.00 | 0.00 | 0.13 | 0.00 | 0.77 | 0.00 |
| Adjusted $R^2$ | 1.00 | 0.00 | 0.14 | 0.00 | 0.76 | 0.00 |

resource planning system awareness. This is a win-win situation for faculty and companies to benefit from the SAP expertise. Companies benefit from having a more sophisticated labor pool from which they can recruit with minimized transition.

In conclusion, business simulation games such as ERP-Sim are building a strong presence with universities as an effective alternative to traditional teaching methods. Business simulation games offer substitutive real-world exposure that aligns to the realism of modern companies in today's business environment.

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