On Manufacturing Sector Performance: Do Information and Communication Technologies Matter?

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ABSTRACT

We analyzed manufacturing industry sector sales performance using a decision tree. The jury is still out regarding the effects of information and communication technologies (ICTs) on firm or industry performance, as previous studies do not provide a clear picture on whether ICTs improve performance. Our investigation found that ICTs alone do not produce significant manufacturing sector performance but several financial factors do. The study helps to inform manufacturing industry policies and management decisions.

Keywords: Information and communication technology, financial context, industry performance, cross-national comparison, manufacturing industry sector, information technology

INTRODUCTION

Information and Communication Technologies (ICTs) help fuel the digital revolution and are vehicles of growth and development in the knowledge economy. This is why companies invest in them to become more competitive (Koivunen, Hatonen, & Valimaki, 2008). The jury is out on whether ICTs improve firm performance, so the debate continues (Piget & Kossaï, 2013) even though evidence suggests they improve productivity, growth and other organizational outcomes, and performance indicators (Botello & Avella, 2014).

Crowston & Myers (2004) identified a lack of industry level research on the effectiveness of ICTs to improve industry performance. Manufacturing industry sector is a catalyst for economic growth (Libanio & Moro, 2006) and bank-lending policies affect manufacturing industry performance (Obamuyi, Edun, & Kayode, 2012). Lending policies fall under the auspices of

financial variables in the World Bank's World Enterprise Survey (The World Bank, 2015) used in this investigation. Consequently, our research goal is to understand the relationships between ICTs in the financial context of manufacturing industry performance.

Towards this goal, we investigate how ICTs and financial factors impact industry performance. In this study, industry performance is measured by manufacturing sales revenue growth. The ICT construct represents the level of technology sophistication among firms and financial factors represent the business context.

LITERATURE REVIEW

Performance

The ability of ICTs to affect performance has been discussed (Piget & Kossaï, 2013). Performance measures include cost reductions, increased flexibility, inventory reduction, reduced cycle time, and so on, while country level effects include increase productivity and gross domestic product (GDP). It is measured in several ways, such as sales and profit (Botello & Avella, 2014), turnover and profitability (Koellinger, 2006), market share, productivity, and growth, debt ratios, and share price (March & Sutton, 1997), employment growth (Baldwin, Raffiquzzaman, & Statistics Canada, 1995), and employee wages (Audretsch, van Leeuwen, Menkveld, & Thurik, 2001). Financial performance includes sales growth, revenue, market share, and social performance includes corporate social responsibility, corporate social responsiveness, and corporate citizenship (Wood, 2010). Macro level performance includes industry, country, or continent improvements, but the effect of ICT on performance varies with time and country (Piget & Kossaï, 2013). It follows that there are several ways to measure performance. Most of the measurements used in prior studies are directly or indirectly related to revenue, which is primarily a function of sales.

The impact of ICTs on performance varies by region and early studies demonstrate no effect of ICTs on performance and productivity in some developed countries (Jorgenson & Stiroh, 1995, 2000). ICTs have a positive effect in developed countries and little to no effect in developing countries. ICTs productivity is higher in the US than in Europe and large differences exist among European countries (Matteucci, O'Mahony, Robinson, & Zwick, 2005). The effect of ICTs on GDP is significant for Asian and Organization for Economic Co-operation and Development

countries, and negative for sub-Saharan Africa (Guitat & Drine, 2007). The conclusion from the literature is the economic impact of ICTs is debatable; some studies demonstrate positive effects, while others do not and the effects vary across different contexts.

Firm performance and growth are significantly constrained by factors, such as the need to connect with banks, banks' lack of money, high interest rates, the adverse impact of bank bureaucracies, collateral requirements, and lack of access to operations financing (Beck, Demirguc-Kunt, & Maksimoic, 2005). Since ICTs enable business processes, and our findings suggest that financial variables are determinants of firm and industry performance, we included them in the analysis.

Research Question

Based on the literature, there is no clear picture on whether and how ICTs impact performance at the firm, industry, and societal levels. In addition, findings suggest differences across regions. Therefore, there is a clear research gap that warrants further investigation. From the preceding discussion, we advance the following research question.

RQ: How do ICTs and financial factors impact firm performance?

METHOD

Using the World Bank's World Enterprise Survey data (Enterprise Surveys, 2015), we focused on the manufacturing sector, which includes 29 industries in 65 countries across Central, and South America, Africa, Asia, Eastern, and Western Europe. The industries include food, garments, other manufacturing, textiles, basic metals/fabricated metals/machinery and equipment, machinery and equipment, chemicals, plastics and rubber, rest of universe-manufacturing, textiles and garments, chemicals and chemical products, leather products, machinery and equipment and electronics, motor vehicles and transport equipment, furniture, motor vehicles, electronics, food/leather/wood/tobacco/rubber products, non-metallic mineral products, electronics and communications equipment, fabricated metal products, rubber and plastics products, basic metals and metal products, minerals, metals, machinery and equipment, printing and publishing, wood products, mining related manufacturing, textiles, garments, leather and paper, chemicals, non-metallic mineral, plastics and rubber, and wood products and furniture.

The target variable of the study is sales revenue growth of each industry. Due to resource limitations, we were unable to use the raw firm data from the survey, as it would require an enormous amount of time to organize and clean the survey data. This is because the surveys were administered differently across various countries. This did not affect the analysis since we used the aggregated dataset containing industry records. Each unit of analysis (or record) in the data set corresponds to an industry in a specific country, in a specific year.

The use of aggregated industry data for analysis addresses Crowston and Myers' charge about the lack of industry level ICT research (Crowston & Myers, 2004). In our study, the industry level data serve as a proxy for firm performance, as industry performance is the aggregated performance of firms in the industry.

Operationalizing ICTs

The ICT construct is represented by five variables defined in the survey under technology and innovation. They are: 1. Percent of firms with an internationally recognized quality certification, 2. Percent of firms using technology licensed from foreign companies, 3. Percent of firms having their own website, 4. Percent of firms using e-mail to interact with clients/suppliers, and 5. Percent of firms with an annual financial statement reviewed by external auditors.

IGI Global, the parent owner of over 180 peer refereed journals, including ICT journals, defines ICT as an umbrella term that includes all technologies for the communication of information. It encompasses any medium to record information (whether paper, pen, magnetic disk/ tape, optical disks - CD/DVD, flash memory etc.). It includes technology for broadcasting information - radio, television – and technology for communicating through voice and sound or images - microphone, camera, loudspeaker, telephone to cellular phones (IGI Global, 2016). By definition ICT includes ecommerce, email, accounting, financial, and manufacturing systems and technologies. Its definition covers a wide range of technologies and could be represented by numerous variables.

The five technology and innovation variables fall under the broad ICT definition. Three of the five are clearly ICTs and two are less obvious. Technologies licensed by foreign companies span the technology spectrum but commonly used ones are Electronic Data Interchange (EDI) for supply chain communication, salesforce.com, and ERP systems. Websites, a major technology in

B2B, B2C and other forms of ecommerce are considered ICTs (Sagi, Carayannis, Dasgupta, & Thomas, 2004). Email is another heavily used ICT technology in business (Yeo & Grant, 2016). The least obvious ones are internationally-recognized quality certification, and having annual financial statements reviewed by external auditors. Pertaining to the former, it can be argued that firms that are more technologically sophisticated are better positioned to receive international awards and certifications. These certifications include the ISO 9001, 9002, or 1400 that are audited by external auditors, and quality certification experts. The information needed to verify quality standards and accounting practices are stored in the company's information systems, such as accounting, financial, operations, and manufacturing systems. These are all ICTs by definition. Regarding the latter, firms that rely on external auditors are using accounting applications, systems, and practices, to communicate their financial and accounting information, and are reliant on ICTs. Many non-U.S. and international companies subscribe to international accounting practices developed by the International Accounting Standards, and the International Financial Reporting Standards. Having external audits imply the use of sophisticated accounting practices and complex electronic business systems, such as accounting and financial information systems. Therefore, it is an indirect measure of a firm's use of ICTs.

Operationalizing the Financial Context

Research suggests that financial factors are a major constraint of firm performance and growth (Beck et al., 2005; Carpenter & Petersen, 2002). Beck et al., (2005) discuss access to financing, high interest rates, bank bureaucracy, lack of money, and collateral requirements that inhibit company performance. Firm performance and growth are constrained by 1. the need for special connections with banks, 2. banks' lack of money, 3. high interest rates, 4. the adverse impact of having to deal with bank bureaucracies, 5. collateral requirements, and 6. lack of access to operations financing (Beck et al., 2005). These constraints influence our decision to represent the financial context of the study with seven financial variables classified in the survey. They are: 1. Percent of firms with a bank loan/line of credit, 2. Proportion of loans requiring collateral, 3. Value of collateral needed for a loan (Percent of the loan amount), 4. Proportion of investments financed by banks, 5. Proportion of investments financed by supplier credit, 6. Proportion of investments financed by equity or stock sales, and 7. Proportion of working capital financed by supplier credit. The seven financial variables address the major constraints discussed by Beck et

al., (2005). Variables 2 and 3 of the study are associated with the collateral requirements constraint. Variables 1, 4, 5 and 6 are associated with interest rates, bureaucracy, or access to finance. Variables 6 and 7 are associated with bureaucracy, high interest rates, collateral requirements, or lack of access to financing (Beck et al., 2005).

Decision Trees

We wanted to investigate the predictors of positive performance, which would aid managerial decisions and industry development policies. Decision trees enable us to identify the key predictors and their corresponding values. Decision trees are non-parametric tools widely used in data mining for classification and prediction (Osei-Bryson, 2004) and in ICT research (Tomic Rotim, Dobsa, & Krakar, 2013). Various decision trees exist, the most popular are Chi-Squared Automatic Interaction Detection (CHAID), Classification and Regression (CART), ID3 (Quinlan, 1986), C4.5 and C5.0 (Quinlan, 1998; Samoilenko, 2008).

A decision tree is primarily a set of decision rules. When applied to a dataset, a decision tree algorithm produces an upside down tree that represents the path along which the partitioning took place. The resultant decision tree consists of four components: root nodes, leaf nodes, decision nodes, and branches. Branches connect nodes to form the tree-like structure, which is the decision tree. The root node is the top of the decision tree and is the starting point of the tree. This is sometimes referred to as the root of the tree.

A decision tree algorithm causes data to split based on splitting rules. The point where each partition takes place is the decision node. Splitting is based on each independent predictor and multivariate splits are possible (Samoilenko, 2008). There are no rules on the number of branches a split may produce, but most decision trees are binary. In a binary tree, each split at a decision node produces two branches, hence the word binary. The decision tree induction process, which is the splitting process, is dependent on stopping criteria. These criteria are used to prevent further splitting of data. Most algorithms use multiple stopping rules and additional rules may be specified. The nodes where no further splitting is allowed are called leaf nodes or terminal nodes (Samoilenko, 2008).

Different types of trees have different splitting methods or rules. CART uses binary splits whereas CHAID allows multiple splits. CHAID uses statistical stopping rules to discontinue tree

growth, whereas CART and C4.5 grow the full tree then prune it back (Shmueli, 2016)**.** Pruning requires the use of the data set and a training set. The tree is pruned until the performance is similar to both sets.

Since the predictors in this study – ICT and financial variables – are continuous variables, we did not want to limit the splitting by using binary splits. Multiple splits provide a richer picture and analysis of the data. Some variables may be better analyzed by having multiple splits versus binary splits. For example, one of our variables, collateral as a percent of loan amount, could take on values from 0 to infinity. In a predictive model, it may be difficult and arbitrary to draw the line using binary splits. We may discover things using multiple splits that could not be discovered using binary splits. Multiple splits may also result in binary splits, but not vice versa. Hence, it is more rigorous and natural to allow the algorithm to determine the splits, rather than force binary splits of the predictors.

Consequently, we chose a CHAID decision tree to identify the variables that predict sales growth. Similar approaches have been used to identify relevant indicators for effective ICT utilization (Tomic Rotim et al., 2013). As we wanted to explore how different ICT and financial predictors affect industry performance, sales growth is computed to represent positive or negative growth. In the data set, all records exhibited either positive or negative growth. This was determined by examining the survey variable that captured sales growth. The branches of the tree explain the variables as predictors through conditional probabilities. The tree shows how the variables work together in tandem to predict the target variable. The results of the model can be used to inform manufacturing industry development polices and management decisions.

Descriptive Findings

The full dataset comprised records from both manufacturing and service industries. There were nearly three times as many instances of positive growth compared to negative growth. As such, the records for negative growth were multiplied by a factor of three to balance the outcomes for training purposes. This does not affect the conditional probabilities inherent in the decision tree. Filtering for manufacturing industries resulted in 587 records for analysis.

In the manufacturing slice of the dataset, 57.48% of the records exhibited positive growth, while 27.82% showed negative growth. The remaining records had missing values for annual sales

growth. A summary of the descriptive statistics for the predictors is given in Table 1. Given that the data for each unit of analysis were not collected every year for the duration of the survey (2006 to 2015), these descriptive statistics should be interpreted with some caution. We discuss the limitation of the dataset further in the conclusion. From the findings, there appears to be substantial variations in the proportion of investments financed by supplier credit, and the proportion of investments financed by equity or stock sales in the dataset.

Predictor	Mean	Std Dev
Percent of firms with a bank loan/line of credit	35.20	22.12
Proportion of loans requiring collateral (%)	75.70	20.57
Value of collateral needed for a loan (% of the loan amount)	169.46	74.22
Proportion of investments financed by banks (%)	16.85	13.96
Proportion of investments financed by supplier credit (%)	5.00	5.85
Proportion of investments financed by equity or stock sales (%)	3.44	6.84
Proportion of working capital financed by supplier credit (%)	13.31	9.30
Percent of firms with an internationally-recognized quality certification	20.03	17.15
Percent of firms using technology licensed from foreign companies	12.43	9.56
Percent of firms having their own website	39.17	24.86
Percent of firms using e-mail to interact with clients/suppliers	65.15	29.31
Percent of firms with an annual financial statement reviewed by external auditors	46.67	25.37

Table 1 Summary of Descriptive Statistics of Predictors

The model predicts 75.55% of the dependent variable (n=587), and indicates that ICTs do not predict industry performance as well as finance variables. The finance variables are better at predicting average positive or negative sales growth among industries. The top five predictors of sales growth in terms of their predictive capability, based on their influence on the decision tree, are: proportion of investments financed by equity or stock sales, value of collateral needed for a loan, proportion of working capital financed by supplier credit, proportion of loans requiring collateral, and proportion of investments financed by supplier credit. They are all financial variables. The only ICT variable is the percent of firms with an annual financial statement reviewed by external auditors. The decision tree is shown in Figure 1.

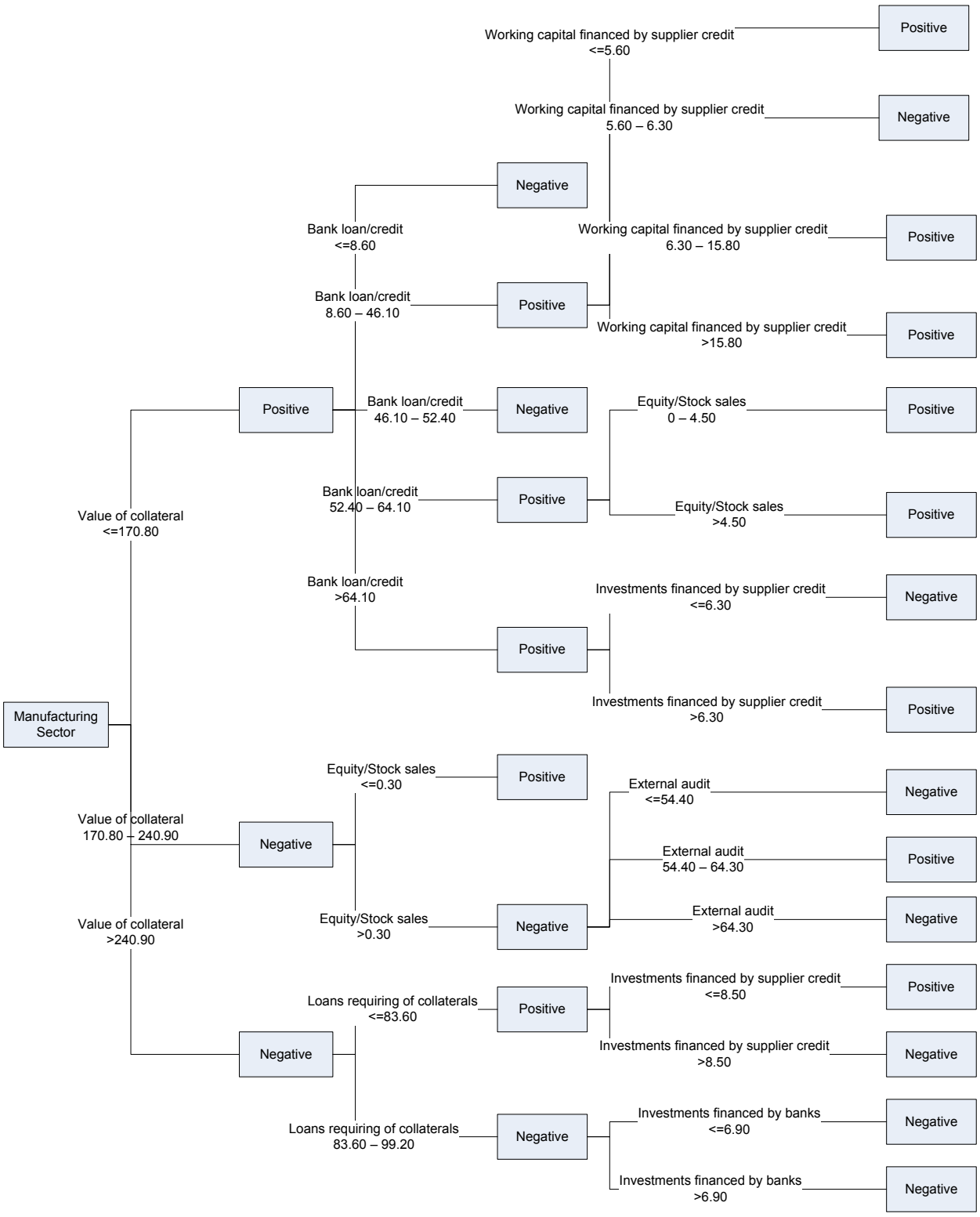

Figure 1 Decision Tree for Industry Sales Growth

DISCUSSION OF FINDINGS

The decision tree shows the variables as nodes. Each node contains a split based on the values, and how they predict positive or negative sales growth. Following the top node, there are three main branches in the decision tree. We will discuss each branch of the tree in the following sub sections.

Branch 1: Low Collateral Needed for Loans

The top node, and split, of the decision tree (see Figure 1) represents the value of collateral needed for a loan as a percentage of the loan amount. This was classified into four categories: less than 170.80%, between 170.80% and 240.90%, more than 240.90%, and missing. We exclude the missing branch, which adds no value to the analysis; this limitation is explained in the discussion section. When the value of collateral needed for a loan was low (<170.80%), most firms experienced positive sales growth ($\chi^2 = 105.50$, $p<0.001$). However, other variables predict sales growth, for example, when industries have a low percentage of firms (<= 8.60%) that have a bank loan or line of credit, they experienced negative sales growth ($\chi^2 = 55.03$, $p<0.001$). This finding shows that the access to finance is an important predictor of firm performance; this is similar to lack of financial access, a constraint to emancipating people from poverty (Cecchini et al., 2003). Low bank collateral requirements make it easier for firms to obtain loans, as there are fewer barriers to securing loans. It is important for companies to take advantage of bank financing and those that did not, experienced negative sales growth. Industries with a higher percentage of firms (>8.60% and <=46.10%) with bank loans or lines of credit exhibit positive sales growth ($\chi^2 = 55.03$, $p<0.001$). We observed that in a financial environment with low collateral requirements and a high percentage of firms that can benefit from bank loans or lines of credit, industries with 5.60% to 6.30% of firms whose working capital is financed by supplier credit, exhibited negative sales growth. The majority of firms, exhibited positive growth ($\chi^2 = 39.94$, $p<0.001$).

Avoiding the use of supplier credit is associated with positive industry performance. The exception is explained by unfavorable supplier terms of credit or bank loans. Firms in these industries that are unable to secure bank financing are at the mercy of creditors with unfavorable terms of credit. Firms with collateral less than 170.80% of the loan in industries with 46.10% to 52.40% of firms with bank loans or lines of credit, experienced negative growth. This finding

appears to contradict an earlier one regarding firms taking advantage of a low collateral opportunities for loans, which led to increased sales. The range however, is small (7.14% of the 210 cases with the value of collateral needed at less than 170.80%), with 26 cases, 15 showing negative growth, nine with positive growth, and two missing. This finding may be an anomaly or error and should be interpreted with caution.

Focusing on the same level of the decision tree, industries that experienced a low collateral required (<170.80% of the loan) and more than 52.40% of firms with a bank loans or lines of credit, experienced positive growth. However, industries with more than 64.10% of firms with a bank loan or line of credit, those that had 6.30% or less of their investments financed by supplier credit experienced negative growth, while those with more than 6.30% experienced positive growth (χ^2 = 8.37, p=0.031). This suggests that the presence of supplier credit as a form of financing, is important to firms that are able to take loans and are in an environment where access to financial support is more easily leveraged by a lower collateral needed.

Branch 2: Moderate Collateral Needed for Loans

From this node, the firms in the industries are required to have collateral between 170.80% and 240.90% of the loan amount. Industries with a low proportion of investments financed by equity or stock sales (<= 0.30%) experienced positive sales growth (χ^2 = 41.66, p<0.001). Fourteen of the 19 cases, showed positive growth and five were missing. Firms that did not rely on stocks or equity for financing increased their valuation. This allows more assets to be used as collateral to take advantage of lending opportunities. It further allows firms to be better positioned to leverage access to finance, which in turn leads to increase sales. Industries with more than 0.3% of investments financed by equity or stocks, exhibit negative growth. The exception was industries with 54.50% to 64.30% of firms with annual financial statements reviewed by external auditors had increased sales growth (χ^2 = 23.75, p=0.003). All nine cases in this category showed positive sales growth. Industries with more than 64.30% of firms with annual financial statements reviewed by external auditors, 81.82% exhibit negative growth. Firms in good financial health tend to be more transparent to the public and external audits enhance their publicity image.

This finding suggests that firms that are externally audited perform better. In this case, industries with a higher percentage of firms externally audited (> 64.30%) should theoretically exhibit positive growth. The evidence indicates that industries with a higher percentage of firms

externally audited (>64.30%), the mean sales growth was 0.78%, and the median sales growth was -1.80%. This indicates a positively skewed distribution with a small but high sales growth (> than 10.00 percent) and the median indicates a larger negative sales growth. However, the strong sales growth performance should not be ignored, so the result should be interpreted with caution, as sales growth was measured as positive or negative, which cannot account for differences in magnitude of performances among industries.

Branch 3: High Collateral Needed for Loans

A high collateral needed for loans implies a restrictive business environment, where borrowing is restricted. This imposes restrictions on firm investments and performance, particularly for small and medium sized firms. It is expected in industries with high collateral of more than 240.90%, industries tended to exhibit negative growth ($\chi^2 = 105.50$, $p<0.001$). Industries with firms where less than 83.60% of loans requiring collaterals, generally experienced positive growth ($\chi^2 = 55.53$, $p<0.001$). Of the nineteen industries, twelve experience positive growth. Industries with an average of less than 8.50% of firms financed by supplier credit, experienced positive growth ($\chi^2 = 19.78$, $p<0.001$). Of the 13 cases, 12 exhibited positive growth, and one was missing.

Considering the restrictive business environment due to high loan collateral, having access to financing with little or no collateral increased access to money. Even in a restrictive financial environment, there may be financial institutions that are willing to provide loans without collaterals. However, the dependence on supplier credit suggests weak performance among firms, which may explain the negative growth exhibited by firms who rely on supplier credit. It may be that supplier credit involves some form of collateral, imposing business restrictions and inhibiting performance.

CONCLUSION

We investigated the effects of ICTs and finance on manufacturing industry sector sales revenue using a decision tree. The aggregated sample of firms comprised several individual manufacturing industries across the world, with the exception of North America. The data consist of five ICT variables and seven finance variables.

Of the five ICT variables, only the percent of firms with an annual financial statement reviewed by external auditors was found to positively influence industry sales performance. However, the

top five predictors of industry sales growth were all financial: proportion of investments financed by equity or stock sales, value of collateral needed for a loan, proportion of working capital financed by supplier credit, proportion of loans requiring collateral, and proportion of investments financed by supplier credit. Given the limitations of the sample, the results should not be taken as universal and should be interpreted with some caution. However, the results are consistent with previous research findings: ICTs do not significantly improve sales performance (Jorgenson & Stiroh, 1995). Financial variables better predict performance, reinforcing the belief that performance is determined by other factors, as opposed to ICTs (Piget & Kossaï, 2013). Inadequate access to finance leads to low firm performance (Libanio & Moro, 2006) and financial liberalization improves firm performance and economic growth (Asamoah, 2011). Evidence of these findings was identified, as access to finance positively influenced firm performance, particularly low loan collateral requirements that make it easier to obtain loans. Industries with firms that avoided using supplier credit performed better, and dependence on supplier credit resulted in weak sales. We conclude that all sources of external funding do not lead to improved sales performance. Industries with firms that have a low proportion of investments financed by equity or stock sales, correlate with positive sales growth.

As a key contribution, this study addresses the lack of industry level research on ICTs (Crowston & Myers, 2004). It helps in understanding the economic impact of ICTs on sales revenue growth among industries in the global manufacturing sector. It also helps to inform companies and policy makers about ICT use and the need to consider financial and other business factors, rather than just ICTs. The findings of the study add to the literature on how ICTs and finance impact manufacturing sector sales revenue. Despite the rapid advancement of ICTs, the financial context continues to be important in influencing firms' performance.

Future Research

A limitation of the study relates to the dataset. We were unable to use the raw data directly from the survey results, had we been able to, the analyses might have provided additional insights. In the analysis, we excluded records with missing data. Although missing data could be imputed, methods of imputation are not appropriate in this case. There are several imputation methods, which depend on corresponding values from other records in the dataset, a baseline that was established prior to the investigation, or before and after values in a longitudinal study sample

(Engels & Diehr, 2003). These methods are not applicable in this study. For example, the lack of prior models on the same dataset prevents the use of baselines for imputation. The data are also not in a time series and firms included in the survey were not surveyed every year. In the aggregated dataset, this means that the same industries are not captured across all years for all countries as in a time series. For instance, Chile has records in 2006 and 2010 only, comprising industries such as chemicals and chemical products (2006), chemicals, plastics and rubber (2010), two records for food in 2006 and 2010. Sweden in contrast, only has records for 2014, covering fabricated metal products, machinery and equipment, and other manufacturing.

Each record is independent. The level of collateral required for a loan in a specific industry in a specific country, and year, has no relation to its corresponding value in another record from another industry, country, and year. Even if there is a relation, the same industry may not appear for all years, and in all countries. As such, imputation using corresponding values and before and after values are not applicable.

In addition to increasing the number of records, expanding the geographical locations may provide different results. Future studies may consider including the U.S. and Canada and differences across locations. Analyzing a more comprehensive dataset may produce more conclusive results. Lastly, future research may explore the findings by geographic region and time, to uncover possible differences with respect to these dimensions.

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