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Are ICTs Really That Important in Driving Industry Performance?

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ABSTRACT

A decision tree is used to investigate how information and communication technologies (ICTs) and financial factors influence the performance of service and manufacturing industries globally. Industry performance is measured by average fixed asset purchases among firms at the industry level. In addition, industry sectors and geographic regions are included in the predictive model. The results show that financial factors are better predictors of performance than ICT factors. For example, access to bank loans or lines of credit is by far the best predictor among the variables included in the study. Having a website is the only ICT factor among the top five predictors. Geography also plays an important role in predicting industry performance.

KEYWORDS

Cross-Region Comparison, Financial Variables, Fixed Asset Purchase, Global, ICT, Industry Performance

1. INTRODUCTION

Industries in developed and developing countries can be dichotomized into two primary categories, manufacturing and service. Most economies often start out as industrial economies based on manufacturing, then transition to post-industrial economies, referred to as service-based economies (Doll & Vonderembse, 1991). Economies, such as the Caribbean, that lack natural resources are often service-based. Its best resources are its people and climate used to develop a tourist-based service economy. Regardless of whether an economy is manufacturing- or service-based, there is a common denominator; the role information and communication technologies (ICTs) play in supporting the economy. ICTs are the information technology (IT) infrastructure components such as computers, software, telephone, data/information networks, data bases, applications, and other IT related technologies that support company operations to satisfy customer demands for goods and services. Irrespective of the type of industry and its stage of development, ICTs play an important role in enabling industry performance and have been referred to as information systems (IS) or IT (Schryen, 2013).

ICTs are catalysts of growth in developed and developing countries (Crowston & Myers, 2004) and support service economies built on ecommerce. This is particularly true in the absence of brick and mortar facilities, such as hotel and travel reservations, online shopping, banking, and

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entertainment. ICTs enable growth and development, and help to create and maintain competitive advantages for companies, countries, and regions (Koivunen, Hatonen, & Valimaki, 2008). They play a prominent role in manufacturing operations that rely on computer support, such as computer-aided design and manufacturing, databases, computer controls and monitoring, and bill of materials and logistics. Flexible manufacturing utilizes intelligent machines and robots, which fall under the broad definition of ICTs. The impact of ICTs on performance is questionable (Piget & Kossaï, 2013; Sein & Harindranath, 2004) despite positive evidence of their impact on economic growth, and other performance indicators (Bloom, Guzzo, Harding, Milligan, & Zahidi, 2013).

ICT research has fueled debate on the factors that drive performance. An ICT meta-analysis indicates that ICT impact findings are partially explained (Schryen, 2013). Researchers are left to figure out which factors influence performance and which do not. There is evidence on the positive impact of ICTs (Schryen, 2013), but the relationship of ICT performance at the industry level is unclear (Devaraj & Kohli, 2000). One reason is the lack of industry ICT research posited by Crowston and Myers (2004), who challenge the IS research community to do more. In addition, bank-lending policies affect company and country performance (Obamuyi, Edun, & Kayode, 2012). In Nigeria for example, bank-lending rates significantly affect manufacturing output, but a relationship between manufacturing output and economic growth cannot be established (Obamuyi et al., 2012). Lending policies encompass more than bank-lending rates, such as financial factors that may enable performance. Researchers are left with little guidance on how to identify potential financial factors that influence global industry performance.

The lack of convincing evidence on the impact of ICTs on company performance, the lack of industry ICT research, and the potential of financial factors on industry performance motivates this investigation. Specifically, we investigate the relationship between ICTs, financial factors, and fixed asset purchases in both manufacturing- and service-based industries. This is exploratory research that endeavors to identify individual factors worthy of future research, thus enriching the current literature. Our research objective investigates which ICT and financial factors influence the purchase of fixed assets in 47 service and manufacturing industries in 11 geographic regions of Central, and South America, Africa, Southeast Asia, South Asia, Central Asia, West Asia, East Asia, Caribbean, Eastern, and Western Europe, from 2006 to 2015. The paper is organized as follows. Section 2 discusses how ICTs influence industry performance, Section 3 the research method, Section 4 the results, Section 5 a discussion of results, and the paper concludes in Section 6 with a discussion on the hypothesis vectors.

2. ICTS AND PERFORMANCE

Debate on the impact of ICTs on company performance, country growth and development, and globalization is ongoing (Akpan, 2003; Cecchini & Scott, 2003; Molla, 2000; OECD, 2008; Piget & Kossaï, 2013). ICT benefits include cost reductions, increased flexibility, inventory reduction, reduced cycle time, improved product quality, increased efficiency, capacity utilization, reduced transaction costs, country benefits, increased productivity, reduced digital divide, and economic growth. There are research gaps stemming from inconsistent industry results on the impact of ICTs (Devaraj & Kohli, 2000), and the lack of industry ICT research (Crowston and Myers, 2004).

Performance occurs at various levels and is measured in several ways (March & Sutton, 1997). Performance measures include profit (Botello & Pedraza Avella, 2014), turnover and profitability (Koellinger, 2006) which are affected by fixed assets investment (Eriotis, Frangouli, & Ventoura-Neokosmides, 2011), sales revenue growth (Yeo & Grant, 2017b), market share, capacity utilization (Yeo & Grant, 2017a), productivity, growth, debt ratios, and share price (March & Sutton, 1997), employment growth (Baldwin, Raffiquzzaman, & Statistics Canada, 1995), employee wages (Audretsch, van Leeuwen, Menkveld, & Thurik, 2001), forms of capital (Hsieh, Rai, & Keil, 2011), and others (Lind, Sepúlveda, & Nuñez, 2000). Additional performance measures include financial,

non-financial or economic, social, micro and macro. Financial performance encompasses sales growth, revenue, and market share, while social performance includes corporate social responsibility, social good, corporate social responsiveness, and corporate citizenship (Wood, 2010).

2.1. Impact From ICTs on Industry Performance

The micro view of performance focuses on individual company performance, viewed as a form of technology investment or utilization (Bankole, Osei-Bryson, & Brown, 2015). Early studies demonstrate a lack of ICT performance impact (Jorgenson & Stiroh, 1995) and Brynjolfsson and Yang (1997) find no relationships between ICTs and U.S. firm performance. However, ICTs have a positive impact on productivity in some developed countries (Jorgenson & Stiroh, 2000), yet an earlier study found no relationship (Jorgenson & Stiroh, 1995). Some studies find no impact on economic growth (Jacobson, 2003) but Lee et al. (2005) find significant ICT impact on economic growth in developed and newly industrialized countries. There is evidence for and against the impact of ICTs on performance. Recent studies indicate ICTs have a positive impact on company performance and productivity (N. Bloom et al., 2010), but earlier studies disagree (Kohli & Devaraj, 2003). Because our data (2006 to 2015) are relatively recent, we propose the following hypothesis vector:

HYPOTHESIS VECTOR 1 (H1): ICTs have a positive effect on global industry performance.

2.2. Industry Characteristics and the Impact of ICTs

Industry characteristics include industry type (manufacturing and service) and geography. The impact of ICTs performance varies with geography (Lee, Gholami, & Tong, 2005; Piget & Kossaï, 2013; Torero & Von Braun, 2006; Yeo & Grant, 2017b). ICTs have higher productivity impact in the U.S., and large impact variations exist in Europe (Matteucci, O'Mahony, Robinson, & Zwick, 2005). Higher U.S. productivity is attributed to early technology adoption, institutional differences (Matteucci et al., 2005), and country infrastructure (Bollou, 2006). ICT performance variations stem from IT infrastructure and institutional quality which affect trade in Africa (Bankole et al., 2015), improves performance in West Africa (Bollou, 2006), positively impact Gross Domestic Product (GDP) in Asian and OECD countries, and negatively impact sub-Saharan Africa (Guitat & Drine, 2007). ICT contribution to GDP in OECD countries, is higher than in developing countries (World Bank, 2016) and Yeo and Grant (2017b) find performance differences among industries in East Asia, Eastern and Western Europe, South East Asia, South Asia, Central America, and Africa. The impact of ICTs also depends on contextual factors such as education, income, wealth, digital divide, and finance (Schryen, 2013), which are related to geographical differences.

The on-going debate on whether service and manufacturing innovation can be analyzed in similar ways (Gago & Rubalcaba, 2007) and the difficulty in measuring the difference in service innovation versus goods innovation (Gago & Rubalcaba, 2007), are reasons to consider industry type in this research. Service measures, such as improved service quality (Zeithaml, Bitner, & Gremler, 2006), cross-functional communication and business strategies (Antioco, 2006), and customer relationships (Christian Kowalkowski, Daniel Kindström, & Heiko Gebauer, 2013) are intangible benefits that result in tangible cost reductions and improved revenue, particularly in industrialized countries where services drive economic growth (Hempell, Leeuwen, & Wiel, 2004). Chou and Shao (2014) studied ICT productivity of service industries in 25 OECD countries and found higher productivity growth than in other countries. Even though ICTs enable new services (Bottini & Tajoli, 2010), their impact on service industries is less studied (Christian Kowalkowski et al., 2013), compared to manufacturing (Hempell et al., 2004). U.S. labor productivity growth between 1995 and 2001 among ICT-using service industries is faster than ICT-using manufacturing industries. During the same period, there was no difference between ICT-using service and manufacturing industries in Europe, as a result of stronger financial institutions in the U.S. (Inklaar, O'Mahony, Robinson, & Timmer, 2003). The effect

of geography, the need to better understand industry type differences, and the lack of ICT impact studies on service industries, lead to the following hypothesis vector:

HYPOTHESIS VECTOR 2 (H2): Industry characteristics such as geography and industry type (manufacturing or service), affect global industry performance.

2.3. The Financial Context

ICTs must be interpreted within their contexts (Pacey, 1983) and value is derived from successful leverage (Taylor, 1996). Variations of ICT performance can be accounted for by considering the financial context to better understand the impact of ICTs on industry performance. There is evidence that a viable financial environment (i.e. financial context) favorable to companies, enable them to exploit ICT use and increase performance. A strong and viable financial industry enables economic growth (King & Levine, 1993) and improves performance (Beck, Demirguc-Kunt, & Maksimoic, 2005; Yeo & Grant, 2017b) by supporting technological innovation (Goldsmith, 1969; McKinnon Ronald, 1973; Schumpeter, 1912). The importance of financial factors has been demonstrated (Asamoah, 2011; Libanio & Moro, 2006a; Park, Kim, & Kim, 2017; Yeo & Grant, 2017b). Bank lending policies improve business performance in developed and developing countries (Obamuyi, Edun, & Kayode, 2012), such as Latin America (Libanio & Moro, 2006a), and Ghana (Asamoah, 2011). Financial factors are strong predictors of industry performance (Yeo & Grant, 2017b). Park et al. (2017) studied ICT services in Korea and found that the ability of companies to invest in facilities is an important barometer of success. This emphasizes the importance of the financial context to companies. Bank-lending policies and external funding affect company, industry, and country performance (see Beck et al., 2005; Gerschenkron, 1962; Obamuyi et al., 2012). Yeo and Grant (2017b) find that financial factors like bank lending policies drive manufacturing industry performance. Based on evidence that financial factors and bank lending policies have a favorable effect on various performance measures, we advance the following hypothesis vector:

HYPOTHESIS VECTOR 3 (H3): Financial factors have a positive effect on global industry performance.

3. RESEARCH METHOD

3.1. Data

The data used in this analysis come from the World Bank's World Enterprise Survey (The World Bank, 2015). The survey is a representative sample of private companies from 11 regions, but the U.S. and Canada are not included. The variables are categorized into 12 topics: corruption, crime, finance, firm characteristics, gender, informality, infrastructure, innovation and technology, performance, regulation and taxes, trade, and workforce. Some industries are not represented every year for every region, and the ICT variables are limited. They do not include technologies such as cloud computing, Internet of Things (IoT), social computing, enterprise systems, business intelligence, data analytics, and other technologies. These limitations are discussed in Section 5, and are circumvented by using decision tree analysis to allow in-depth insights to be drawn, thus adding value to the extant literature. We address the lack of industry research by utilizing the industry aggregates from the raw data, so each unit of analysis represents an industry in a specific country, in a specific year.

3.2. Variables

Our variable selection stems directly from the literature review. They are grouped into three hypothesis vectors: the ICT vector, the industry characteristics vector, and the financial context vector. The first

vector includes four ICT variables from the technology and innovation category, the second includes two variables on industry characteristics available in the survey, and the third vector comprises seven finance variables from the finance category in the survey. Some variables are applicable only to manufacturing, so we selected those that pertain to both. The four ICT variables in the ICT hypothesis vector are: 1. Percent of firms with an internationally recognized quality certification, 2. Percent of firms having their own website, 3. Percent of firms using e-mail to interact with clients/suppliers, and 4. Percent of firms with an annual financial statement reviewed by external auditors. External audits may not appear to represent technology and innovation directly, but indirectly, the reliance on accounting practices and IT to support external audits implies they do.

The industry characteristics hypothesis vector comprises geographical regions and industry type (manufacturing or service). As discussed in our literature review, these can influence the impact of ICTs (World Bank, 2016). Studies on the impact of ICTs from different geographical regions have different results (see Brynjolfsson & Yang, 1997; Guitat & Drine, 2007; Jacobson, 2003; Kossaï & Piget, 2014; Lee et al., 2005; Matteucci et al., 2005; Yeo & Grant, 2017b). Scholars argue about whether manufacturing and service industries are similar during analyses (Gago & Rubalcaba, 2007). We argue, based on our literature review, that they are different, and there is a lack of studies on the impact of ICTs on service industries (Christian Kowalkowski et al., 2013). Inklaar et al. (2003) show that ICT-using service industries experienced faster labor productivity increases than their manufacturing counterparts in the US, but there is no difference between them in Europe. Therefore, we include both industry types in the analysis. Taken together, the industry hypothesis vector, that reflects industry characteristics, includes both their geographic regions and type (manufacturing and service).

The financial context is represented by seven variables: 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 (% of the loan amount), 4. Percent of firms not needing a loan, 5. Percent of firms whose recent loan application was rejected, 6. Proportion of investments financed by banks, and 7. Percent of firms identifying access to finance as a major constraint. As discussed in the literature review, the financial context is important for ICT-driven industry performance. A viable banking sector supports technological innovation (Goldsmith, 1969; McKinnon Ronald, 1973; Schumpeter, 1912). Industries benefit from bank lending policies in both developed and developing countries (Obamuyi et al., 2012), and the importance of financial factors to industry and regional performance has been demonstrated in several studies (Asamoah, 2011; Libanio & Moro, 2006a; Park et al., 2017; Yeo & Grant, 2017b). The lack of access to bank financing, banks' lack of money, high interest rates, the adverse impact of bank bureaucracies, collateral requirements, and lack of access to operations financing are significant constraints to company performance (Beck et al., 2005), and influence our decision to include financial variables. The interest rate constraint informs our selection of the first, fifth, sixth and seventh variables, collateral informs the second and third variables, and bank bureaucracies and lack of access to operations financing directly or indirectly informs the selection of all the variables.

3.3. Decision Tree Overview

The data limitations rule out the use of regressions and influence our decision to use a decision tree, a data mining technique widely used for classification and prediction (Osei-Bryson, 2004, Wang, Li, Cao, & Yuan, 2006). Our methodological rationale is based on two reasons. First, our predictors comprise both continuous and categorical variables. Second, we seek to establish specific ranges of predictor values and their corresponding predicted outcomes, thus adding depth to our analysis. Decision trees allow us to address both. Decision trees work well with non-linear relationships between variables, and no data distribution assumptions are necessary (Pal & Mather, 2003). It can process continuous and categorical variables and has been applied to marketing (Amir, Osman, Bachok, & Ibrahim, 2015; Díaz-Pérez & Bethencourt-Cejas, 2016; Kim, Timothy, & Hwang, 2011;

Legohérel, Hsu, & Daucé, 2015) and medicine (Kobayashi, Takahashi, Arioka, Koga, & Fukui, 2013; Murphy & Comiskey, 2013; Rodríguez et al., 2016; Ture, Tokatli, & Kurt, 2009), and ICTs (Grant & Yeo, 2018; Yeo & Grant, 2016, 2017, 2018). Decision trees are seldom used in ICT research compared to traditional statistical methods, although they can provide a richer analysis of data (Osei-Bryson and Ngwenyama, 2014).

The two most popular decision trees are Classification and Regression Trees (CART) and Chi-Square Automatic Interaction Detector (CHAID). They employ recursive partitioning to split a data into subsets. The splitting continues until there is no significant relationship between the remaining variables and the target variable (Díaz-Pérez & Bethencourt-Cejas, 2016). Each CART node is split into exactly two child nodes until the subsets pertaining to the target variable, are homogenous (Ture et al., 2009). In contrast, CHAID enables multiple splits (Shmueli, 2016) where each node can have two or more child nodes (Berry & Linoff, 1997). Splitting rules are determined by the chi-square test of association, which measures the goodness of fit between observed and expected outcomes. The predictor in each split that best determines the outcome of the target variable is the one with the lowest p-value from the Chi-square tests (Legohérel et al., 2015). The ICT and financial variables of the study are continuous and we did not want to limit the analysis to binary splits. When continuous variables take on infinite values are identified as predictors in CART, they are partitioned into binary subsets, high and low. CHAID supports the partitioning of two or more subsets that best determine the outcome of the target variable. These influence us to choose CHAID.

3.4. Industry Performance in Research Model

The literature review discusses ways to measure performance, and one is fixed assets investment that affects firm profitability (Eriotis et al., 2011; Grant & Yeo, 2018), an indicator of financial health. Industry performance is the aggregate performance of firms in an industry for a given time period. In this study, the target or dependent variable is the percent of companies in a manufacturing or service industry that purchase fixed assets. It is a proxy for industry performance and is computed as a binary variable using binning, where the median is used as the cut-off point to divide records into two categories, resulting in an equal number of observations on either side of the median. Values regarding the percent of firms buying fixed assets ranged from 2.30% to 91.80%. Industries with less than or equal to 43.60% of firms buying fixed assets are coded as weak performance, and those with more than 43.60% are coded as strong. Figure 1 represents the research model that comprises three hypothesis vectors – technology innovation, industry characteristics, and financial context – which affect industry performance. The vectors comprise independent variables that affect the target or dependent variable, the percent of firms in an industry buying fixed assets.

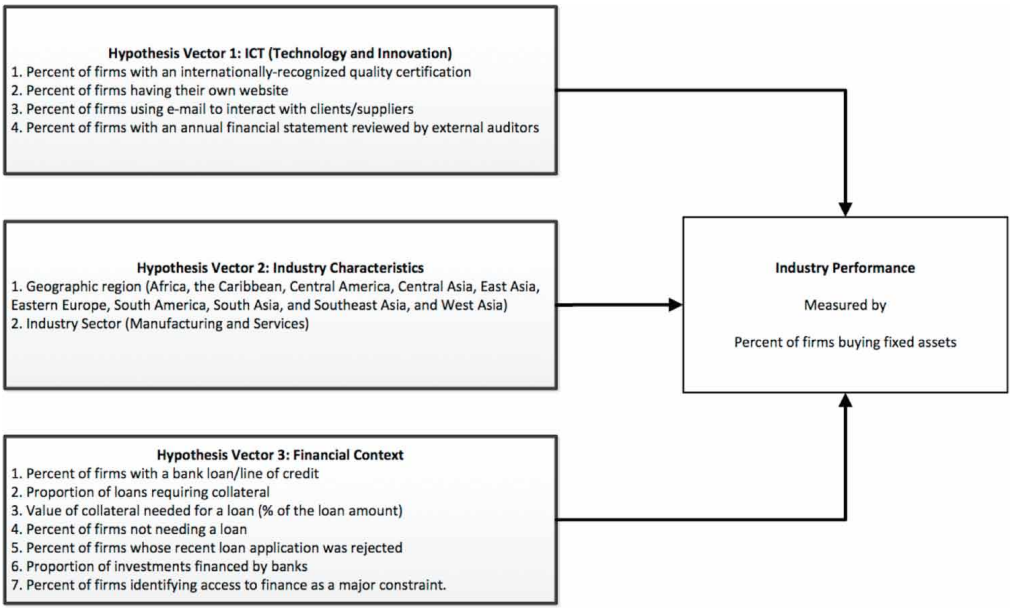
4. RESULTS

4.1. Predictors of Industry Performance

The predictors of industry performance, operationalized as the percent of firms buying fixed assets, is determined by a Chi-Square Automatic Interaction Detector (CHAID) decision tree. Finance and ICT variables, along with industry region and sector, are included in the model. The decision tree (Figure 2), predicts 77.37% of the dependent variable correctly (n=751). The results indicate that ICT variables are less important than financial variables in predicting industry performance, and the industry region is a significant determinant of industry performance.

The top five predictors of industry performance and their corresponding level of importance, are shown in Figure 3. The percent of firms with a bank loan or line of credit is the most important determinant, followed by the percent of firms having a website. Next, in descending order of

Figure 1. Research Model



importance, are the percent of firms identifying access to finance as a major constraint, the industry region, and the percent of firms not needing a loan.

The top split of the decision tree (Figure 4) is the percent of firms with a bank loan or line of credit. This is classified into six branches: less than or equal to 6.50%, between 6.50% and 18.50%, between 18.50 and 25.20%, between 25.20% and 45.20%, between 45.20% and 62.30%, and more than 62.30%. We classified these six branches, based on the percentages, as very low, low, moderately low, moderately high, high, and very high level of reliance on bank loans or lines of credit. They are discussed in the following sections.

4.2. Branch 1: Very Low Reliance on Bank Loans

Industries classified in this branch have less than or equal to 6.50% of firms with a bank loan or line of credit ($\chi^2 = 212.414$, $p < 0.001$). Most firms in this branch have low industry performance. The next split is the percent of firms identifying access to finance as a major constraint: those with less than or equal to 56.0% of firms, have weak performance, while those with more than 56.0% have strong performance ($\chi^2 = 10.209$, $p < 0.011$). Among those with less than or equal to 56.0%, those that have an average of between 69.20% and 98.20% of loans requiring a collateral, have strong performance, while those outside of this range, have weak performance ($\chi^2 = 17.967$, $p=0.012$). These findings may seem unexpected but upon further scrutiny, we find at Node 8, among the industries with more than 56.0% of firms identifying access to finance as a major constraint, 40.0% (n=8) had weak performance, and 60.0% (n=12) had strong performance. Given that the distribution is almost even, this finding should be interpreted with caution.

Looking at Node 19, there are 13 industries with less than or equal to 56.0% of firms identifying access to finance as a major constraint, and between 69.20% and 98.20% of loans requiring a collateral. Among these, eight have strong performance, and five do not. Given the small number of industries in this node, the finding that these industries performed well should be interpreted with caution.

Figure 2. Decision tree for industry performance

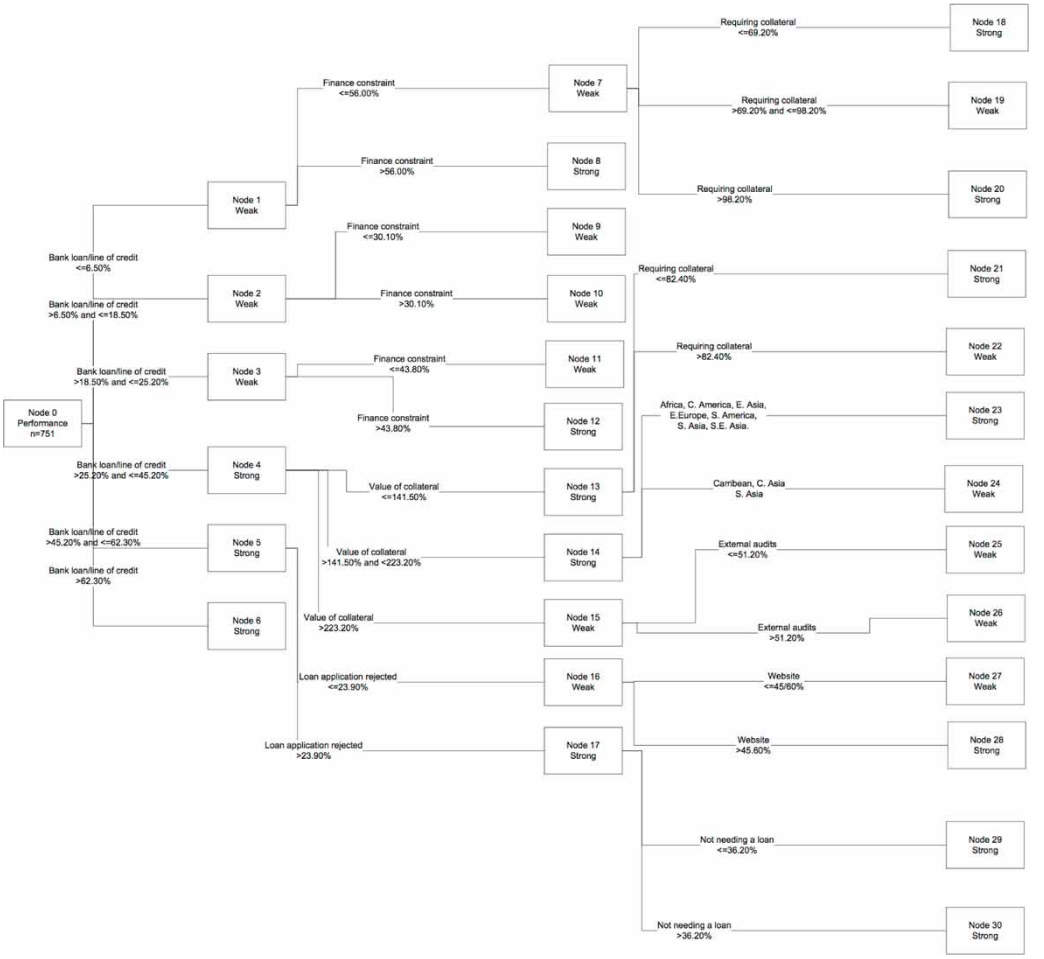
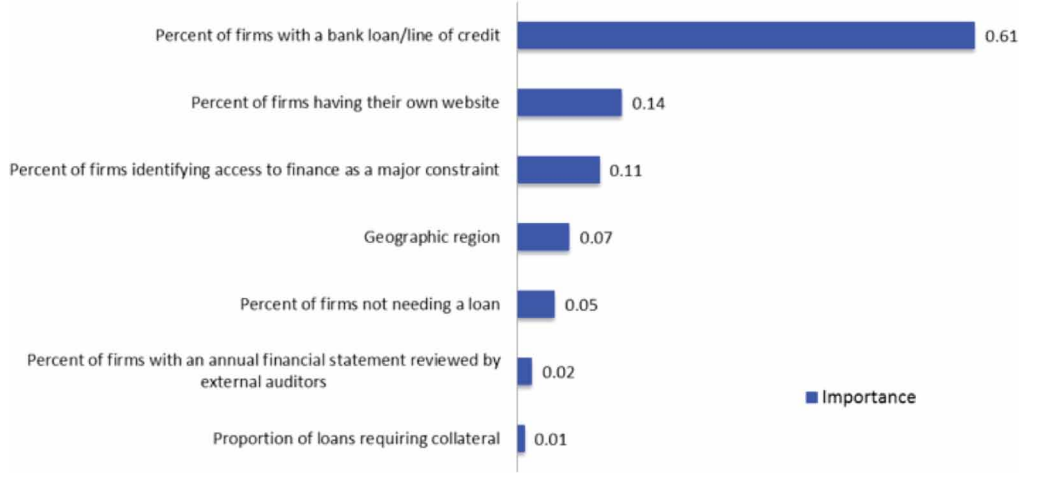


Figure 3. Predictors of performance



4.3. Branch 2: Low Reliance on Bank Loans

Industries in this branch have more than 6.50% and less than or equal to 18.50% of firms with a bank loan or line of credit ($\chi^2 = 212.414$, $p < 0.001$), have weak performance. Among 148 industries classified in this branch, only 23 had high industry performance. This suggests access to bank loans or lines of credit is important in determining industry performance.

4.4. Branch 3: Moderately Low Reliance on Bank Loans

Industries in this branch have more than 18.50% and less than or equal to 25.20% of firms with a bank loan or line of credit ($\chi^2 = 212.414$, $p < 0.001$). Most industries have low or weak performance, and of the 75 industries, 12 have strong performance. These are industries with more than 43.80% of firms identifying access to finance as a major constraint ($\chi^2 = 16.436$, $p<0.001$). One might expect not relying on bank loans is a sign of a healthy financial situation that should result in above average asset purchase performance. However, low performance suggests that company funds can be better utilized. Another explanation for low performance is the high loan rejection rates experienced by companies. This may be the chicken and the egg dilemma; is the low reliance on bank loans due to choice, or is it due to high loan interest rates? There is no way to tell from the data.

4.5. Branch 4: Moderately High Reliance on Bank Loans

Industries in this branch have more than 25.20% and less than or equal to 45.20% of firms with a bank loan or line of credit ($\chi^2 = 212.414$, $p<0.001$). Most industries have strong performance and among the 232 industries classified in this branch, 121 have strong performance, while 111 have relatively weak performance. The subsequent split explains the findings in more detail. In this branch, industries that have an average of less than or equal to 141.50% of their loans requiring a collateral have strong performance ($\chi^2 = 24.816$, $p < 0.001$). In the next split, Nodes 21 and 22 show that industries that have less than or equal to 82.40% of loans requiring collateral, have strong performance, while those with more than 82.40% have weak performance ($\chi^2 = 12.768$, $p = 0.003$). This suggests that access to finance is important for industry performance. Industries that do not require high collaterals and do not have many financial loans that require collaterals, perform better.

In Node 14, industries have a collateral average of 141.50% and 223.20% of loans. In the next split, most industries in Africa, Central America, East Asia, Eastern Europe, South America, South Asia, and Southeast Asia have strong industry performance, while those in the Caribbean, Central Asia, and West Asia have relatively weak performance ($\chi^2 = 16.456$, $p < 0.025$). It is important to note that in Node 23, comprising industries in regions that have strong industry performance, 55.96% ($n = 61$) have strong performance, compared to 44.04% ($n = 48$) with weak industry performance. In Node 24, all 11 industries have weak performance. In the same branch, industries that require collateral of more than 223.20% of the loans, the highest value of collateral in the sample, have weak performance. This reinforces our earlier argument that reasonable levels of loan collateral, are beneficial to industry performance.

4.6. Branch 5: High Reliance on Bank Loans

Industries in this branch have more than 45.20% and less than or equal to 62.30% of firms with a bank loan or line of credit ($\chi^2 = 212.414$, $p < 0.001$). Most industries have strong performance. However, industries with less than 23.90% of firms, whose recent loan application was rejected, have weak performance ($\chi^2 = 24.622$, $p < 0.001$). Those that have more than 45.60% of firms with a website, have strong performance ($\chi^2 = 10.529$, $p = 0.009$). The industries in this branch have a relatively high percent of firms with bank loans or lines of credit (between 45.20% and 62.30%). Therefore, in an environment where access to loans is not a problem, firms should continue to innovate and derive value from their operations. Based on this study, innovation can result from ICTs, thus explaining the above finding.

Industries with more than 23.9% of firms with their recent loan application rejected, have strong performance ($\chi^2 = 24.622$, $p < 0.001$). However, 59.8% (n=70) of the industries have more than 36.2% of firms not needing a loan. Loan rejection can be due to stringent requirements of financial markets, such as high loan collateral. Therefore, these industries are likely to be operating in financial markets with significant barriers to loan financing. In addition, this finding may appear to be an anomaly and is discussed in the limitations section.

4.7. Branch 6: Very High Reliance on Bank Loans

Industries in this branch have more than 62.30% of firms with a bank loan or line of credit ($\chi^2 = 212.414$, $p < 0.001$). Industries have strong performance and among the 72 industries, 92.44% (n = 68) have strong industry performance, reinforcing that access to bank loan or lines of credit financing, is instrumental to industry performance.

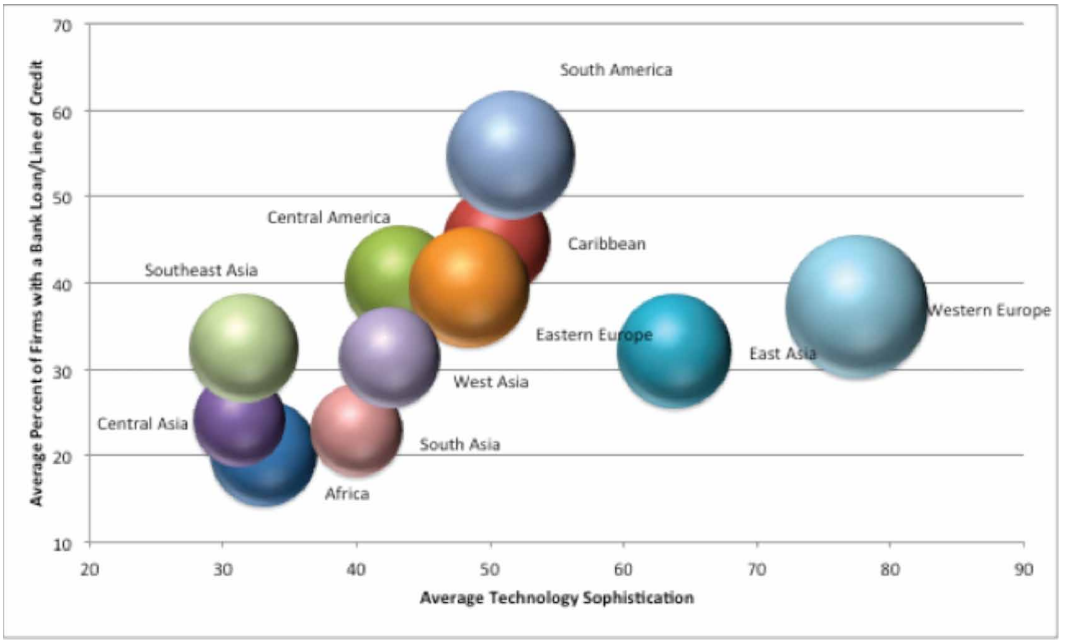
4.8. Regional Comparisons

Industry regions is an important top five predictor of industry performance, so we explored the technology sophistication differences among them. This is accomplished by using the ICT-related variables; two of which, the percent of firms having their own website, and the percent of firms with an annual financial statement reviewed by external auditors, are among the top six predictors of performance. We computed a technology sophistication measure by averaging all four ICT-related variables. Figure 4 shows the cross-region comparison of three measures: average technology sophistication, average percent of firms with a bank loan or line of credit, and industry performance, operationalized by the percent of firms buying fixed assets. The latter is denoted by the size of the bubble in Figure 4.

4.9. Loans/Line of Credit, and Industry Performance

The comparisons indicate differences among the regions. Values of industry performance in the sample range from 2.30% to 91.80%, with a mean of 43.98%, and a standard deviation of 18.12.

Figure 4. Cross-region comparisons of technology sophistication, firms with a bank



The regional variations are somewhat noticeable, judging from the size of the bubbles. For example, Western Europe is clearly larger than South or Central Asia, indicating a higher percent of firms buying fixed assets. Closer examination reveals that industries in the Caribbean have reasonably high technology sophistication and a high percent of firms buying fixed assets, but Africa is comparatively low on both measures. However, the average industry performances of both regions are similar, 40.37% and 40.13% respectively. Both South Asia and Central Asia are comparatively low on average technology sophistication and percent of firms with a bank loan or line of credit, and have weak industry performance of 29.47% and 30.56% respectively. Western Europe has the strongest industry performance of 72.17%, and high average technology sophistication, but a moderate percent of firms with a bank loan or line of credit, similar to East Asia. East Asia has moderate industry performance of 46.14%, ranking fourth among the regions in performance, but has a relatively high technology sophistication. These regional comparisons suggest that higher technology sophistication regions with higher access to bank loans or lines of credit may have stronger performance, although the picture is not very noticeable. It is plausible that culture, politics, society, economics, education, income, wealth, digital divide, and finance (Schryen, 2013), play a role in influencing industry performance. They can be considered extensions of geographical differences.

5. DISCUSSION AND CONCLUSION

5.1. Summary

We address the need for more ICT industry research on performance (Crowston and Myers, 2004), the lack of consistent industry results on the impact of ICT performance (Devaraj & Kohli, 2000), the role of financial factors on industry performance (Yeo and Grant, 2017b; Grant and Yeo, 2018a, 2018b), the effect of geography and industry types, by conducting an exploratory global industry performance study on manufacturing and service industries in Africa, Caribbean, Central America, Central Asia, East Asia, Eastern Europe, Western Europe, South America, South Asia, and Southeast Asia, and West Asia. The research objective seeks answers to three hypothesis vectors using a decision tree to identify predictors of industry performance. The research model is 77.37% accurate in predicting industry performance. Studies show that ICTs alone may not improve performance (Guitat & Drine, 2007; Hsieh et al., 2011; Jacobson, 2003; Jorgenson & Stiroh, 1995), and the impact of ICTs can be better understood by considering the context (Pacey, 1983; Taylor, 1996), so we include financial variables because they affect performance (Beck et al., 2005; Yeo & Grant, 2017b).

Our conclusions regarding the three hypotheses are as follows. Pertaining to H1: ICTs have a positive effect on global industry performance, we find supporting evidence that the use of websites improves industry performance, but not in a significant way. It is far less important than access to bank loans or lines of credit. We posit that the effect may be mitigated by other factors such as finance and geography, and results from the use of ICTs may vary, when they are used differently (see Baard & Nel, 2011; Golja, Paulisic, & Slivar, 2015; Guitat & Drine, 2007; Visser & Weideman, 2011). For H2: Industry characteristics, including geography and industry type (manufacturing or service), affect global industry performance, we find supporting evidence for geography and insufficient evidence for industry type. Some studies show that ICTs are effective in driving performance in developed countries (Jorgenson & Stiroh, 2000; Lee et al., 2005), and our findings show that strong technology sophistication coincides with strong industry performance in Western Europe, the most developed region with high technology sophistication. However, industries in South America have lower technology sophistication and strong performance. The impact of ICTs varies with geography (Piget & Kossaï, 2013; Torero & Von Braun, 2006; Yeo & Grant, 2017b) and contingent upon financial and other contextual factors, such as education, income, wealth, and the digital divide (Schryen, 2013) that are also important to industry performance. For H3: Financial factors have a positive effect on global industry performance, we find supporting evidence to accept the hypothesis vector. We identify five predictors of global industry performance. Listed in order of importance, they are: 1. The percent of

firms with a bank loan or line of credit; 2. The percent of firms having a website; 3. The percent of firms identifying access to finance, as a major constraint; 4. The industry region; and 5. The percent of firms not needing a loan. Of these predictors, the first, third and fifth are financial, the second is ICT-related, and the fourth is geographical region. The top predictor, a finance variable, is by far the most influential, and this is corroborated in the literature (see Asamoah, 2011; Beck et al., 2005; King & Levine, 1993; Libanio & Moro, 2006a; Park et al., 2017; Yeo & Grant, 2017b). Finance plays a more prominent role in driving industry performance, than ICTs or geography.

5.2. The Impact of ICTs and Finance on Performance

The impact of ICTs on performance is inconclusive (Brynjolfsson & Yang, 1997; Lee et al., 2005; Matteucci et al., 2005). While some studies illustrate insignificant effects (Jorgenson & Stiroh, 1995), others conclude otherwise (N. Bloom et al., 2010; Guitat & Drine, 2007; Lee et al., 2005). Our findings support both views. Among the most influential factors on performance, ICTs come second. The most influential factor by far, the percent of firms with a bank loan or line of credit, is a finance variable with a relative importance measure of 0.61. Next is the percent of firms having their own website, an ICT variable at 0.14. Only two of the four ICT variables have a positive impact on performance. The other one (percent of firms with annual financial statement reviewed by external auditors) is largely unimportant, with a relative importance of 0.02. The remaining two ICT variables have no effect on industry performance. Non-ICT factors play a role in influencing performance (Piget & Kossaï, 2013) and access to finance and external funding, improve company performance (Asamoah, 2011; Gerschenkron, 1962; Libanio & Moro, 2006b). In our study, the percent of firms with a bank loan or line of credit is a strong predictor of performance. Of the top five predictors of performance, three are financial. A company's ability to purchase fixed assets, an indicator of financial health, influences turnover and profitability (Eriotis et al., 2011), and is thus, an appropriate measure of performance because they are used to replace old equipment or expand operations. Fixed asset purchases are funded by bank or equity financing, and to a lesser extent by company revenue. Bank or equity financing, indicates that lenders perceive borrowers to be in good financial health, therefore, irrespective of industry type, access to financing is important. This corroborates the prior evidence positing the importance of a strong financial system (see Beck et al., 2005; King & Levine, 1993; Yeo & Grant, 2017b).

5.3. Effect of Regions on Performance

Geography is the fourth important variable in predicting industry performance. When region is combined with technology sophistication, the average percent of firms with a bank loan/line of credit and industry performance, regional differences are not noticeably influential (see Figure 4). We discover varying levels of performance, independent of the level of technology sophistication and access to loans/line of credit. Caribbean industries with high technology sophistication perform well, but African industries perform poorly. Western Europe has strong performance and strong technology sophistication, but South and Central Asia have low technology sophistication and low performance. The literature suggests that the impact of ICTs varies by geography (Lee et al., 2005; Piget & Kossaï, 2013; Torero & Von Braun, 2006; Yeo & Grant, 2017b). We find mixed results as no clear trends emerged, suggesting contextual factors such as education, income, wealth, digital divide, and finance may affect the impact of ICTs (Schryen, 2013). The survey does not shed light on the type of firms surveyed, which may further explain the results. It is possible some service and manufacturing industries do not require significant capital, thus reducing the need to invest in fixed assets. The level of labor-intensity versus capital-intensity in different regions may thus be important in explaining the results. Economic and social conditions determine the need to purchase fixed assets. In underdeveloped countries, manufacturing is not advanced by western standards, but is appropriate for regional economic development. In highly developed regions, capital equipment is utilized to improve efficiency but in Africa, manual labor is the cure for high unemployment. In Southern Africa,

51% of women and 43% of men are unemployed (Devlin, 2013), so it may be financially prudent to employ workers to dig trenches rather than to use machinery. Fixed asset purchases, under these conditions, may not be the best measure of performance.

5.4. Effect of Websites on Performance

There is a perception that websites have advantages for customers and companies alike but this may be true only when they are optimally used (Baard & Nel, 2011). Companies believe that they expand market shares, and lead to increased sales and revenue. This is particularly true for service industries, where websites are the primary conduit for B2C to B2B ecommerce. B2C may be more important for service companies, but B2B is more important to manufacturing companies that seldom sell to individuals, as intermediaries satisfy final consumer demand. We find websites have a positive effect on industry performance. However, poorly designed websites can negatively affect GDP in sub-Saharan Africa (Guitat & Drine, 2007), due to companies in Egypt, Kenya, Morocco, Nigeria and Tunisia failing to optimally utilize them to effectively communicate with investors (Baard & Nel, 2011). Design, security, reliability, trust, and usability requirements (Golja et al., 2015) that constitute good web design (Visser & Weideman, 2011) are often missing. Loan rejection rates may impact the maintenance of websites, thus reducing their effectiveness in places like Africa, with low levels of Internet presence (Baard & Nel, 2011). Since industries from Africa are included in the study, understanding the role of websites and funding to develop and maintain them, may shed light on future industry performance studies.

5.5. Theory Development

In addressing the on-going debate on the effectiveness of ICTs to drive performance (Aral & Weill, 2007; Dedrick, Gurbaxani, & Kraemer, 2003; Hitt & Brynjolfsson, 1996), we take a small and important step in developing theory on the ability of ICTs, geographical region, and financial factors to influence industry performance. We demonstrate that the impact of ICTs should be studied within their contexts for more useful conclusions to be drawn, thus addressing the inconsistencies in the literature regarding the impact of ICTs (N. Bloom et al., 2010; Brynjolfsson & Yang, 1997; Jacobson, 2003; Jorgenson & Stiroh, 1995, 2000; Kohli & Devaraj, 2003; Lee et al., 2005).

The impact of the financial context on industry performance is clear, as access to borrowing is a significant predictor of industry performance. To a lesser degree, the use of websites positively impacts performance. If websites are optimally used, they can be highly beneficial to industry performance (see Baard & Nel, 2011). In theorizing the impact of ICTs, it is not ICTs per se, but their successful leverage that is important in generating value (Taylor, 1996). This is because the impact of ICTs is dependent on other factors (Piget & Kossaï, 2013), and technologies must be interpreted within their contexts (Pacey, 1983). We find corroborating evidence that the impact of ICTs across geographical regions exist (Lee et al., 2005; Piget & Kossaï, 2013; Torero & Von Braun, 2006; Yeo & Grant, 2017b) and geography is less important than financial factors. Our regional comparisons suggest other contextual factors discussed earlier (Schryen, 2013), can affect regional performance and further aid the understanding of how ICTs affect performance.

5.6. Contributions, Limitations and Future Research

This investigation makes six contributions. First, it identifies ICT, geographical, and financial variables that drive industry performance. Second, it identifies potential factors worthy of future research via the hypothesis vectors. Third, it utilizes the seldom used fixed asset purchase variable, as a proxy for industry performance, adding another ICT performance measure. Fourth, service and manufacturing companies benefit from knowing what drives performance. Policy makers can use this knowledge to implement policies that govern lending and ICT use, and managers use it to aid capital expenditure decisions. They can also use the findings to improve trust in ecommerce and vocational ecommerce technology education. Fifth, our findings add to the extant literature on the impact of ICTs on industry

performance. Given the inconsistencies, the scope of our study demonstrates the range of contextual factors – financial, geography and industry type – that may influence the impact of ICTs. We posit that future studies on the impact of ICTs should continue to include contextual factors to better explain their impact, thus addressing the inconsistencies. Lastly, it demonstrates the relative importance of financial factors compared to geography and ICTs, on industry performance.

The charge from Crowston and Myers (2004) to pursue ICT research at the industry level is challenging, due to the lack of access to global high-quality industry data, and resources to collect global data on this scale, thus reducing global comparative studies in the literature. These global surveys are mostly administered by large, international organizations such as United Nations, World Bank, or International Monetary Fund with global reach. Access to comprehensive global data is expensive for faculty and universities, and language barriers and culture pose additional challenges for primary data collection. Industries in some countries are unequally represented, and this may limit the choice of research methods to analyze data. More complete data improve analysis and a wider selection of research methods. The data exclude the U.S. and Canada, but their inclusion would better represent the developed regions. We recommend expanding the ICT variables to include cloud computing, Internet of Things (IoT), social computing, enterprise systems, business intelligence, and data analytics and expanding the finance variables where applicable.

Future studies should explore the effectiveness of websites, their design, and maintenance on industry performance. Trust affects ecommerce differently in various regions (Garnik, 2004) and considering it may shed light on how regional differences affect ICT-driven performance. Access to financing and loan rejection rates are opportunities to study performance in developed and developing regions. Factors that have no effect in this study may be impactful in other regions, where data are available, because they are still part of the context of ICTs. Hence, we recommend their continued inclusion in future studies.

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