ICT Impact on Productivity: Exploring Implications of Females in the Workforce

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ABSTRACT

Information and communication technologies (ICTs) bring heightened promise of productivity, but research shows that the ability of organizations to leverage ICTs is dependent on the workforce. It is argued that technologies are engendered, leading to speculations about the role of female employees in leveraging ICTs. In this exploratory study, we investigate relationships among workforce characteristics, female participation, and capacity utilization across industries in different countries from 2006 to 2015. The results suggest that workforce training and international certifications affect productivity.

Keywords: Information and communication technologies, workforce, gender, industry productivity, cross-country comparisons

BACKGROUND

Information and communication technologies (ICTs) enable task and process executions more accurately by improving the utilization of installed capacities (Nightingale, 2003). Microelectronics and telecommunications simplify the management of information and the coordination of activities by increasing levels of utilization and reducing production idle time, which improve production efficiency (Marini & Pannone, 2007). ICTs improve productivity in companies, nations, and economies by improving agricultural processes (Adejo et al., 2013), reducing poverty (Adebo & Ewuola, 2005), improving software design (Paetz, 2011), facilitating economic growth and development, improving the performance of companies (Yeo & Grant,

2016), enhancing e-commerce (Sagi, Carayannis, Dasgupta, & Thomas, 2004), and improving other performance indicators (Bloom et al., 2010; Botello & Avella, 2014).

There is conflicting evidence regarding the impact of ICTs on productivity. A study by Brynjolfsson (1993) provides a balanced discussion on the productivity paradox of ICTs. The findings involved a literature review of thirty leading journals in information systems and economics. The paradox points to several studies on the successes and failures of ICTs to improve productivity. Some CEOs question their investments in information technologies (IT), yet they continue to invest nonetheless. The paradox may be the result of not being able to effectively measure the contribution of IT, stemming from a lack of good quantitative measures. Weill demonstrated significant productivity increases for transaction processing systems (TPS) but none for strategic systems (Weill, 1990). Measuring productivity gains of TPS is easier than measuring productivity of strategic systems. This suggests two problems, knowing what to measure and how to measure it. This may explain why measuring productivity in service industries is more challenging than measuring productivity in manufacturing (Brynjolfsson, 1993). The lack of good productivity measures is one explanation for the IT productivity paradox, another is how and what to measure. Clearly, there is a need for more research.

This research is in part motivated by notions that technology and human activity should be analysed together, and not treated as separate constructs (Adedeji, 2012). First, workforce and socioeconomic factors help to leverage ICTs, illustrating the importance of the human element in analysing relationships between ICTs and productivity (Hilbert, 2011; Hsieh, Rai, & Keil, 2011). Second, Adedeji posited that individuals' cultural activities give meaning to their experience of science and technology, and vice versa. Third, users require time to fully exploit ICT capabilities (Zhang et al., 2007), suggesting a lag between users capability and productivity. Regarding gender, the use of ICTs in different contexts, such as geography, country, and culture, have different implications. The United Nations conference on trade and development in 2014 posits gender inequality is a human rights issue and makes a strong economic case for promoting equality (United Nations, 2014).

Our research objective explores the relationships between ICTs, capacity utilization, female participation in the workforce, and the role of female in management from a global perspective. We are trying to identify hints about these relationships since they are not well understood in the

literature. To effectively measure productivity, we need to know what to measure and how to effectively measure it. They both play a role in the measurement problem discussed by Brynjolfsson (1993). Having a better understanding of what to measure will help to identity future research directives to be investigated using more rigorous scientific approaches, such as predictive and regression analysis.

LITERATURE REVIEW

Early studies demonstrated a lack of ICT impact on performance (Jorgenson & Stiroh, 1995), yet ICTs are known to have positive impact on productivity in developed countries (Jorgenson & Stiroh, 2000). A measure of productivity is the input to a system compared to the maximum output within a particular time frame (Marini & Pannone, 2007). Capacity utilization measures the gap between actual and maximum output capacity to ascertain system utilization. The use of ICTs increases the accuracy of production tasks by improving capacity utilization (Nightingale, 2003).

The value of information systems depends on its perceived use (Taylor, 1996). In a technologically driven environment where technologies play a role in enhancing productivity, ICTs do not become substitutes for human workers. Instead, the skills required to operate and leverage ICTs become increasingly complementary with technological advancements (Houghton & Sheehan, 2000). A strong and highly skilled workforce is necessary to facilitate economic growth (Yeo, 2014), which is dependent on the performance of its industries.

Literature on gender differences regarding the use of ICTs, suggest that the impact of ICTs maybe mediated by these differences. ICT use is more common among men than women and Basu (2000) argues that technologies are implicitly designed to cater to men's needs, and women have negative attitudes towards ICTs (Varank, 2007). According to Hilbert (2011), women use ICTs to socialize and men use it for the experience. There is evidence that women mostly engage in repetitive, menial, and low paying ICT jobs, fuelling speculation about the role played by contextual factors such as education, training, social, politics, and cultural factors (Tabuwe et al., 2013).

The use and impact of ICTs differ across countries. In some developing countries, the disparities across gender with respect to ICT work, are narrowing (Rice & Katz, 2003), but gender differences remain. There is anecdotal evidence of ICT experiences between men and women,

and women in rural South India experience a lack of access to ICTs and training (Best & Maier, 2007). Women are increasingly empowered by ICTs, especially in the developing world (Davis, 2007), enabling them to overcome discrimination, inequality, poverty, and support their connections to the world at large (Hilbert, 2011). Changes in the relationship between women and ICTs in the developing world exist, but the role of women in using ICTs for productivity remains unanswered (Hilbert, 2011). It is difficult to dismiss the importance of female workforce characteristics in analysing the impact of ICTs on capacity utilization and productivity. The leveraging of ICTs is workforce-dependent (Hilbert, 2011), and women play an important role in using technology (Paetz, 2011), so we include workforce and management characteristics in the investigation.

Studies suggest the effect of ICTs on productivity is mixed (Sigala, 2003; Brynjofsson, 1994) and Crowston and Myers argued for more industry level research on the impact of ICTs (Crowston & Myers, 2004). Crowston and Myers argue that ICTs have the potential to transform entire industries, so they advocated the need for additional research. This benefits academia and industry by aiding the understanding of how technology benefits both constituencies. Industries benefit from the improved understanding of how to enhance the structuring of firms and their competitiveness (Hammer, 1996; McFarlane, 1984; Porter, 2001). They propose that we study ICTs from three industry perspectives: economic, institutional, and socio-cultural. This and the lack of overwhelming evidence of ICT productivity, and the mixed results of ICT effect on workforce and gender, motivate this investigation.

Research Question

Adedeji (2012) argued that technology and human activity should be measured together. Hilbert (2012) and Hsieh (2011) advocate that we analyse the relationships between ICTs and productivity. Hilbert (2011) argues the role of women in using ICTs on productivity is unanswered, and Paetz (2011) argue that women play an important role in using technology. In addition, the effect of ICTs on productivity is mixed (Brynjolfsson, 1993; Sigala, 2003). These arguments suggest there is a connection between the various concepts in addition to the call for more industry level ICT. Consequently, we developed the research model in Figure 1, the details of which are discussed in the next section.

The study is an exploratory attempt or opportunity to better understand how these loose relationships between ICTs, workforce, female gender and management characteristics, affect global industry capacity utilization. A better understanding of the relationships helps us determine future research directives. To this end, we advance the following research question.

RQ: How do the use of ICTs, female gender, workforce and management characteristics, affect industry capacity utilization globally?

METHOD

Variables and Operationalizations

The need for more industry level research and analysis by Crowston and Myers requires the use industry level data. The dataset must enable us to investigate the relationships among ICTs, gender, workforce, and productivity from a global industry perspective. To accomplish our research objective, the data must include variables that are associated with gender, workforce, ICTs, and productivity. It turns out that the World Bank Enterprise Survey data set includes them (The World Bank, 2015).

The data are industry aggregated by country and year, compiled by a representative sample of private firms in 29 industries in 65 countries spanning several geographical regions, including Central, and South America, Africa, Asia, Eastern, and Western Europe, from 2006 to 2015. The World Bank categorized the variables into 12 different topics: corruption, crime, finance, firm characteristics, gender, informality, infrastructure, innovation and technology, performance, regulation and taxes, trade, and workforce. We include variables from the innovation and technology, gender, and workforce categories to capture the ICT and workforce characteristics discussed in the literature.

Each record in the aggregated industry data set corresponds to an industry in a specific country, in a specific year. For example, the basic metals and metal products industry in China in 2012, 52.50% of them had female participation in their ownership. Hence, the value of this variable in 2012 is 52.50%.

From the data set, the five variables under innovation and technology are: 1. Percent of companies with an internationally recognized quality certification, 2. Percent of companies using technology licensed from foreign companies, 3. Percent of companies having their own website,

4. Percent of companies using e-mail to interact with clients/suppliers, 5. Percent of companies with an annual financial statement reviewed by external auditors. They represent a firm's use of ICTs and constitute the primary independent variables of the study on the impact of ICTs on productivity.

We are unclear how the first and fifth variables, as defined in the survey, are directly related to ICT innovation and technology, as no explanation is provided. Our explanation is that internationally recognized quality certifications require the use of business practices and technologies that would be considered innovative, to some companies. Higher technological sophistication, process improvement, and improved business performance are reasons for pursuing international awards. Quality-certified firms in general, and highly-rated Capability Maturity Model firms in particular, have superior operational performance (Issac, Rajendran, & Anantharaman, 2003). The British Standard Institute claims that ISO 9001 certifications reduce cost by 50% and operational performance and customer satisfaction by 75%. External audits imply sophisticated accounting and electronic business systems, enable efficient and effective business practices that culminate in improved capacity utilization (British Standards Institute, 2016). The Security and Exchange Commission (SEC) makes considerable effort to achieve fair, liquid and efficient capital markets worldwide, by providing investors with information that is comparable, transparent, and reliable ("SEC Concept Release: International Accounting Standards.," n.d.). Its action ensures companies have a common benchmark for comparing financial and accounting information. In the absence of a common benchmark (that is, international standards), it would be difficult to compare financial performance across companies, industries, cultures, and geographies.

The impact of ICTs has not been well established due to the mixed results discussed earlier. Hence, it is difficult to determine exactly which ICTs to investigate and how to operationalize them. From the variables classified under technology and innovation in the World Enterprise Survey, there is insufficient evidence to warrant removing any of them from the analysis. Given the research goal and its exploratory nature, we include all five ICT variables. Therefore, workforce is represented by four variables, taken from the workforce category of the data set. They are: 1. Proportion of workers offered formal training, 2. Number of permanent full-time workers, 3. Number of temporary workers, and 4. Proportion of unskilled relative to all production workers. Considering the relevance of gender in using technology, we include female

participation and management in the workforce in the analysis. This is captured by four variables under the gender category in the dataset: 1. Percent of companies with female participation in ownership, 2. Percent of companies with a female top manager, 3. Percent of companies with majority female ownership, and 4. Proportion of permanent full-time workers that are female.

The literature review suggests that female participation in the workforce makes a difference in the use and impact of ICTs. However, the literature regarding the impact of ICTs is unclear on how best to measure female participation. The literature also does not clearly explain the relationship between female participation and other workforce characteristics. Hence, we include workforce, and female participation in management and ownership as a single construct, by combining them and taking the average. Combining them streamlined the analysis so as to represent the lower and upper levels of management. This is further explained in the next paragraph.

Of the four gender variables, the first three have substantial overlaps and are related to female participation in the ownership and management of firms. Some firms have female participation in management but no participation in ownership, resulting in missing values in the dataset. This is sometimes dependent on the culture and would be inappropriate to penalize a firm (or industry) for having female management but no female involvement in ownership, or vice versa. In this study, we are interested in the role of females in the top management, which may include ownership. This differs from female participation at the employee level. Hence, we computed the average of the first three variables as a single variable, resulting in two female participation measures shown in Figure 1.

Figure 1 represents the relationships of the model that are under investigation in the study. The five ICT variables are proxies for technological sophistication. Workforce and management characteristics include both workforce characteristics and female participation. We investigate their impact on industry capacity utilization, a proxy for productivity.

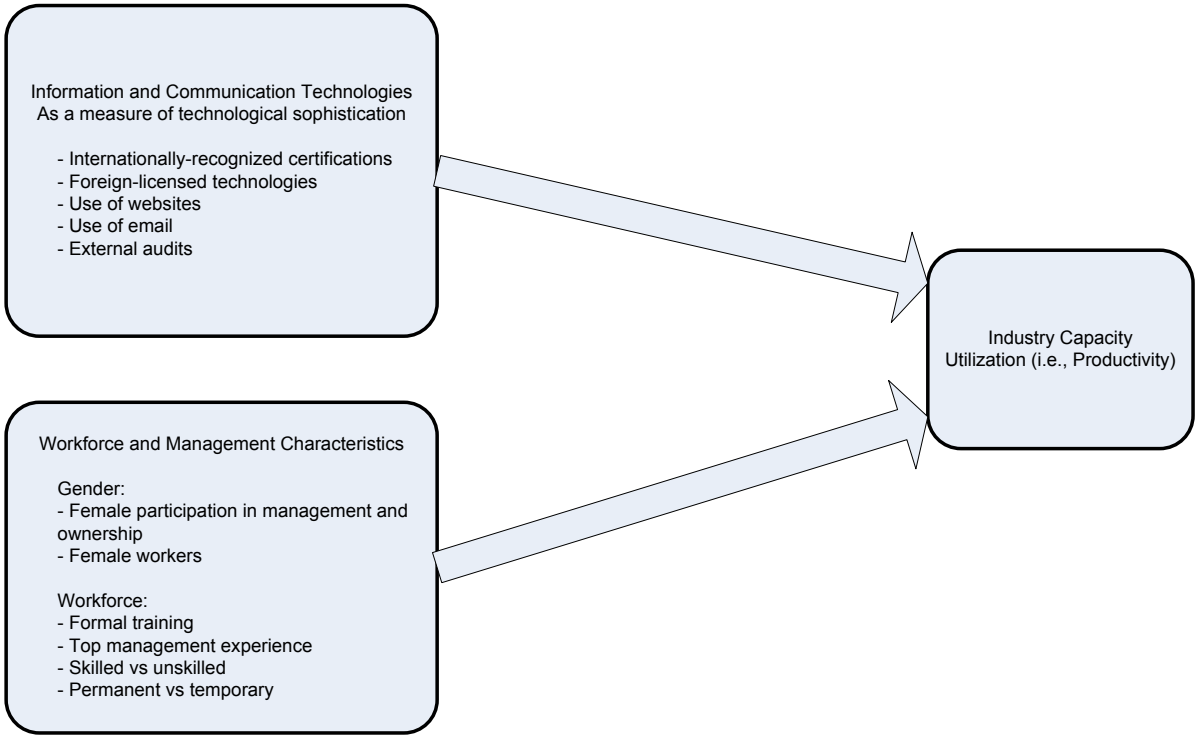

Figure 1: **Summary of Variables under Investigation**

Methodological Rational

The literature is vague on the relationships between to gender, workforce, ICT, and productivity. Hence, we decided to use descriptive analyses to get a better understanding of the importance of the relationships among the variables. The understanding gained in the process provides the impetus to take a more scientific approach to understand the relationships. This is accomplished by using Pearson correlation analysis to dig deeper into the data. The values in the survey data are represented by percentages, which make them non-discrete. Hence, Pearson correlations are appropriate in analyzing the relationships.

Our work is exploratory and because we are searching for hints on the relationships of the variables, it is appropriate to initially investigate the relationships using descriptive analyses. There are more rigorous techniques to consider, but since we lack a good understanding of the relationships, we refrain from using them until a better understanding of the relationships is established.

Figures 2, 3, and 4 in the results section represent the descriptive analyses. Figure 2 represents capacity utilization, technology sophistication, and workforce training by year. The purpose is to identify the trends and relationships between ICTs, workforce training, and capacity utilization. Figure 3 represents capacity utilization, technology sophistication, and female participation, to identify possible relationships among them. Figure 4 represents cross-regional comparisons of female participation at two levels of management and capacity utilization; the lower level represents the workforce, and higher level represents female participation in management and ownership. Figure 4 is actually a four-way comparison between female participation in the workforce (the lower level), management and ownership (upper level), capacity utilization, and region. The size of the bubble represents capacity utilization. The purpose of the figure is to gain a basic understanding of the relationship of the four variables in the figure. In summary, these figures were created to explore loose relationships among the variables discussed earlier.

RESULTS

Other parametric or non-parametric scientific techniques for analyzing data exist, such as regressions and decision trees. The exploratory nature of the study suggests the need to look at how variables are related, so as to develop directions for future research. Methodologically, it is possible for a predictive model to show a weak relationship when there is an actual relationship. Over fitting or under fitting a model can result in biased results. For instance, in the context of this study, we are not certain whether female participation in a firm at the upper and lower levels of management can possibly lead to different impacts on productivity. We are also unaware of which workforce variables are likely to be more important. Including too many variables in a model may be counter- productive and lead to insignificant results when in fact, including a handful of the variables would produce significant results. On the contrary, excluding variables that would otherwise yield significant results would lead to a shallow interpretation of the findings. The computation of the variables can also affect the accuracy of predictions. As such, we adopt a descriptive approach to explore possible relationships. The aim is to aid the development of more rigorous methods of analysis.

Capacity Utilization and Information and Communication Technologies

A summary of means and standard deviations of the variables is shown in Table 1. The findings indicate that industries in the dataset had a moderately high capacity utilization (M = 72.92%,

SD = 7.61). In 2009, non-metallic mineral products industry in Indonesia was the most productive, with an average company utilization capacity of 91.00%. However, in 2011 the textile and garment industry in Zimbabwe had an average company capacity utilization of only 42.90%. Nonetheless, the relatively small standard deviation suggests that records are not widely dispersed.

The ICT variables indicate that industries do not use email extensively to communicate with clients and suppliers. The standard deviation suggests some industries use email extensively for business, while others do not (M = 65.03%, SD = 29.36). This moderate to low mean coupled with a moderate to high standard deviation is common among industries across the ICT variables, percent of companies with an internationally recognized quality certification (M = 20.00%, SD = 17.13), percent of companies having their own website (M = 39.10%, SD = 24.87), and percent of companies with an annual financial statement reviewed by external auditors (M = 46.60%, SD = 25.38), the exception was companies using licensed technology from foreign companies (M = 12.42%, SD = 9.55).

Consequently, there is less variation in the workforce variables as shown. The ones that varied the most were the number of permanent full-time workers and temporary workers appear to vary more than the others (M = 65.38%, SD = 62.34; M = 7.89%, SD = 10.08 respectively). Female ownership and management, as well as the proportion of permanent female full time workers varied to a lesser extent (M = 25.85%, SD = 16.76; M = 27.65%, SD = 18.96 respectively).

These findings suggest that the level of ICT use overall vary more than productivity levels. Therefore, there may be other factors that are driving productivity or that these factors do not affect changes in productivity levels to a large extent. Therefore, in predicting the impact of ICTs on productivity, these and other factors could be taken into consideration.

Variable	N	Mean	Std. Deviation
Capacity utilization	371	72.92	7.61
Percent of firms with an internationally-recognised quality certification	376	20.00	17.13
Percent of firms using technology licensed from foreign companies	371	12.43	9.55
Percent of firms having their own website	375	39.10	24.87
Percent of firms using e-mail to interact with clients/suppliers	373	65.03	29.36
Percent of firms with an annual financial statement reviewed by external auditors	376	46.60	25.38
Female ownership and management	369	25.85	16.76
Proportion of permanent full-time workers that are female	371	27.65	18.96
Proportion of workers offered formal training	332	56.38	16.00
Number of permanent full-time workers	376	65.38	62.34
Number of temporary workers	376	7.89	10.08
Proportion of unskilled workers	321	31.33	13.28

Table 1: Summary Statistics

Trends

Since the survey was administered in 2006 to 2015, it would be useful to explore trends in capacity utilization and how they changed with respect to other variables in the study. The average capacity utilization by year among all industries ranged from a low of 61.79% in 2011 to a high of 80.41% in 2012 (Figure 2). Data from 2015 were excluded from the trends investigation because Bhutan was the only country surveyed. Figure 2, indicates yearly capacity utilization fluctuations with the exception of 2011. This outlier behavior is attributed to the 2011 global recession. This general fluctuation pattern is also seen among technology sophistication (computed by averaging the ICT variables values by industry and year), and training, with the exception of 2008. All three graphs mirror each other from 2010 to 2014. Could the difference between the shapes of the graphs from 2006 to 2009 be the result of a lag between training, technology sophistication, and capacity? The lag is consistent with the idea that users need time to familiarize themselves with technology to fully exploit its productivity (Zhang & Lee, 2007) and leveraging ICTs is workforce-dependent (Hilbert, 2011).

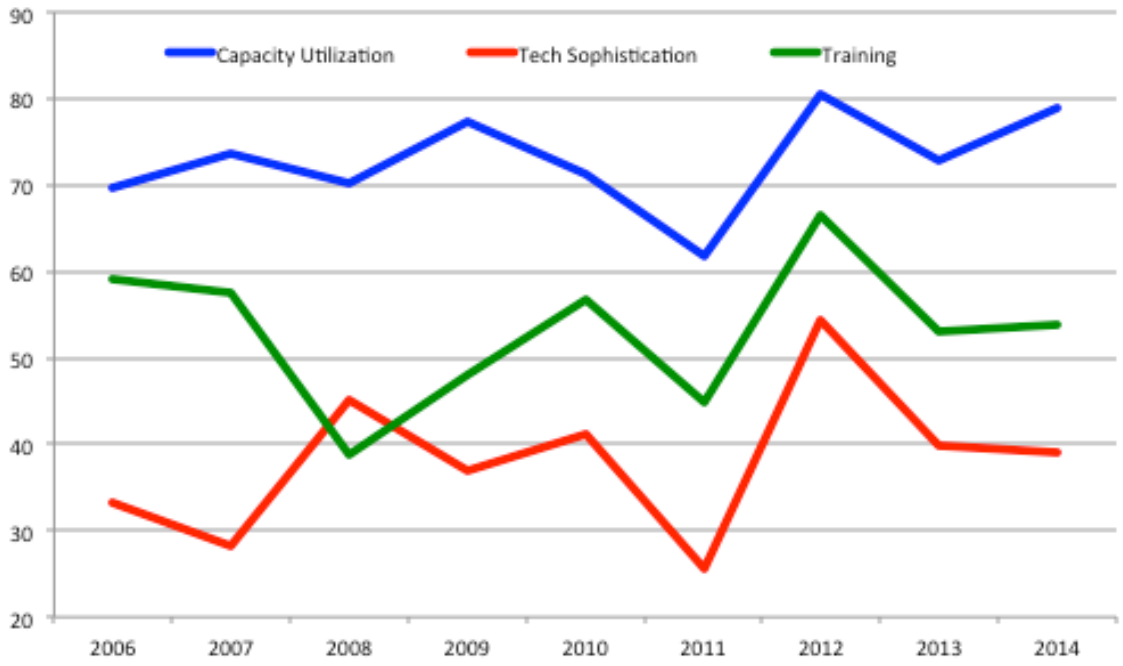

Figure 2: Average Capacity Utilization, Technology Sophistication and Workforce Training by Year

The mirror images of the graphs from 2010 to 2014 reinforce findings from earlier studies that establish employee training results in better leveraging of technologies, which leads to increased productivity. We are aware that descriptive inferences do not imply causality.

We now explore trends of female participation in the workforce and management (see Figure 3). Female participation values were obtained by averaging gender variables by industry and year.

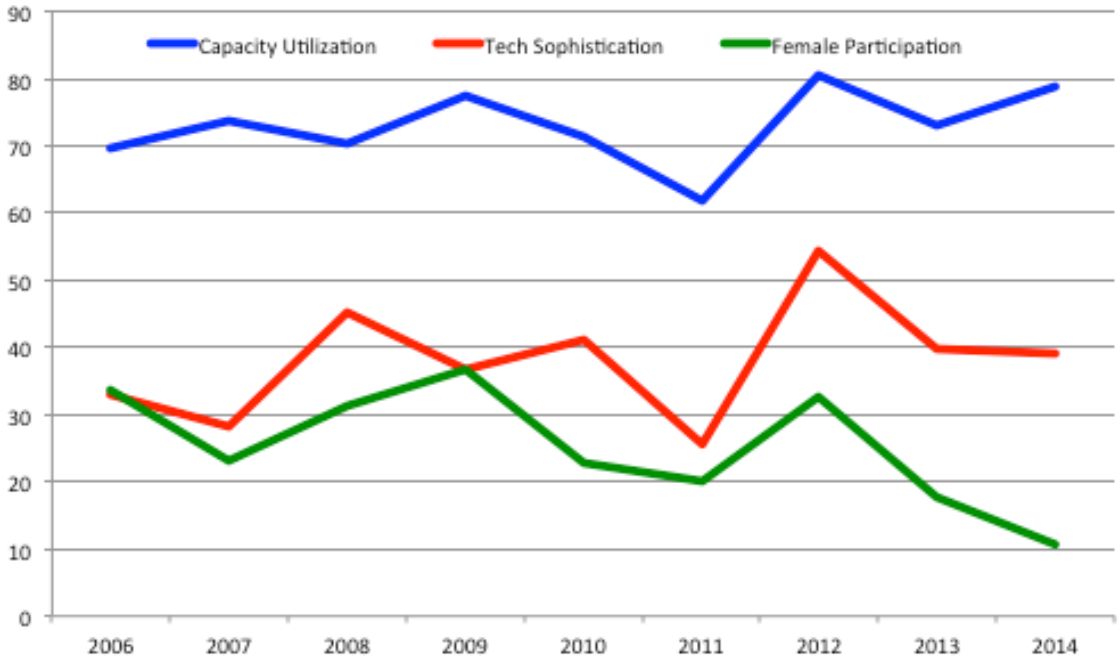

Figure 3: Average Capacity Utilization, Technology Sophistication and Female Participation in Workforce and Management by Year

The levels of female participation and management mirror the levels of technology sophistication from 2006 to 2014. A slight variation is that female participation declined in 2013 more significantly than technology sophistication. All three curves share some similarities from 2009-2010 to 2014 suggesting a relationship between them. The highest technology sophistication, and capacity utilization occurred simultaneously in 2012. Interestingly, technology sophistication was at its lowest point at 25, in 2011, which corresponds with the lowest capacity utilization. Technology sophistication was higher in 2012 to 2014, compared to the previous years, and this is true for capacity utilization. However, the downward trend in technology sophistication from 2012 to 2014 was not evident in capacity utilization. Interestingly, female participation in the workforce and management exhibited a similar downward trend. It declined significantly after 2012, to its lowest point in 2014, even though female participation, and technology sophistication were in tandem before 2012. Global capacity utilization was at its peak in 2012 and 2014.

Regional Comparisons of Female Participation

It is likely female participation and its concomitant implications differ across countries and culture. We explored these differences in nine geographic regions by averaging the values by region (Figure 4). The vertical and horizontal axes represent female participation in the workforce, and female participation in management and ownership respectively. The size of bubbles represents ranked regional capacity utilization. For example, East Asia has the largest capacity utilization hence it is the largest bubble in Figure 4, and West Asia has the smallest capacity and the smallest bubble. In essence, Figure 4 represents the relationships between geography, female participation in the workforce, participation in management and ownership, and capacity utilization.

The average capacity utilization values in the dataset varied from 69.04% to 86.36%, resulting in little differences with respect to the variables on the axes. Without an established pre-existing benchmark, it is difficult to categorize capacity utilization levels to determine what constitutes high, low or even moderate levels of productivity. Therefore, in an attempt to compare the regions, we can only ascertain these levels with respect to the other regions in the dataset. And given that the range of capacity utilization is small, we ranked each region capacity utilization level in reverse order to amplify the differences among them for exploratory analysis. However, it is important to note that the findings from this figure only serves to explore possible differences across regions for further investigation and must be interpreted with caution.

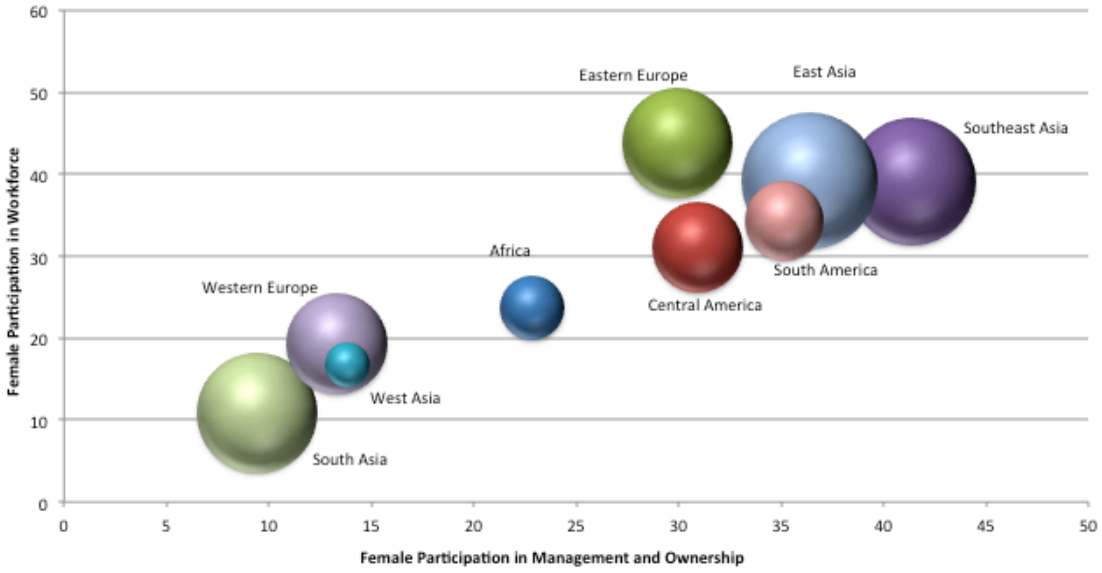

Figure 4: Cross Regional Comparisons of Female Participation and Capacity Utilization (Size of Bubble)

Regions with high female participation in the workforce tend to have high female participation in management and ownership, and vice versa. Eastern Europe had the highest average female workforce participation of 43.79%. The lowest is South Asia with 10.89% and Southeast Asia with the highest average female participation in management and ownership of 41.42%. South Asia with 9.42% was the lowest.

As mentioned, East Asia had the highest capacity utilization with 86.36% and West Asia the lowest with 69.04%. Since the range of average capacity utilization levels was low, inferences on female participation and capacity utilization should be interpreted with caution. Although we cannot be certain of the relationship in Figure 3, regions with higher capacity utilization appear to have higher female participation, based on ranked capacity utilization in Figure 4. These findings suggest that female participation at the ownership and managerial, versus the general workforce levels, with respect to capacity utilization may be similar. As such, datasets that include only female participation at all levels may be sufficient to capture the dynamics of female participation with respect to the impact of ICTs on productivity, without having to distinguish between the levels. At the same time, given that South Asia and Southeast Asia both have similar levels of capacity utilization but markedly different levels of female participation, there may be cultural differences across regions, as discussed in the literature review. As such, including cultural variables may help refine the analysis of the impact of ICTs and female

participation on capacity utilization. These cultural variables are not captured in this dataset but may be obtained from other sources, for future analysis.

Which Factors Matter?

Given the descriptive findings in the preceding sections, we proceeded to run a Pearson correlation between independent variables and capacity utilization to explore the relationships further. These two-tailed bivariate relationships indicate how each variable varies with another, with no assumption of causality. They are useful in enriching the descriptive analyses. The findings are summarized in Table 2. Probability values of less than 0.001 are denoted as .000 in the table.

Variable	r	p	n
Percent of firms with an internationally-recognised quality certification	0.210***	.000	371
Percent of firms using technology licensed from foreign companies	0.055	.297	371
Percent of firms having their own website	0.112**	.037	370
Percent of firms using e-mail to interact with clients/suppliers	-0.020	.630	368
Percent of firms with an annual financial statement reviewed by external auditors	-0.022	.622	371
Female ownership and management	-0.003	.534	369
Proportion of permanent full-time workers that are female	0.095	.072	371
Proportion of workers offered formal training	0.267***	.000	332
Number of permanent full-time workers	0.199***	.000	371
Number of temporary workers	-0.046	.069	371
Proportion of unskilled workers (out of all production workers)	-0.183***	.000	364
** Significant at 95 per cent confidence level.			
*** Significant at 99 per cent confidence level.			

Table 2: Correlations of Variables with Capacity Utilization

From the results, it is clear that industries that have internationally recognized certifications are those with higher capacity utilization levels ($r = 0.210$, $p<0.001$). In addition, having a higher proportion of workers who had formal training and more permanent workers correlated positively with capacity utilization ($r=0.267$, $p<0.001$; $r=0.199$, $p<0.001$ respectively). On the contrary, a high proportion of unskilled workers correlated negatively with capacity utilization ($r=-0.183$, $p<0.001$). These reinforced our findings from Figure 1 that training is likely to be an important predictor of capacity utilization, which should not come as a surprise. However, the role of training, in the context of female participation, would be a useful research direction for predictive modeling.

Interestingly, both gender variables did not correlate significantly with capacity utilization. This and the findings from Figure 4, reinforce the argument that the impact of female participation on capacity utilization does not differ across different levels of the firm. The relationship between female participation and capacity utilization is also not straightforward. National cultural variables may be used as control variables.

DISCUSSION AND CONCLUSION

Our analyses could be more rigorous, but it is important to keep in mind that our research is exploratory. We are trying to identify hints on how variables are related. We are not trying to confirm or refute any particular hypothesis, because we don't know enough. Theories on these relationships are clearly under developed so we are trying to gain a better understanding of the relationships among variables, to identify future research directives. In this section, we discuss the key findings from the descriptive analyses that led to these directives that may support future predictive analyses to understand how variables affect productivity.

From the descriptive analyses, we proceeded to execute a Pearson correlation to explore the relationships among the variables. We corroborated our descriptive analyses findings that higher technological sophistication in the form of ICT use and leverage lead to higher capacity utilization. Specifically, Pearson correlations show that among the five ICT variables used in the study, internationally recognized certifications and the use of websites are important variables to consider, given their significant correlations. These should be taken into consideration in the proposed research directives that follow in the upcoming sections. However, it is important to note that the correlations are small, and should be interpreted with caution.

Pearson correlations also verify that training is important, which is not surprising, given the importance of human intervention in leveraging ICTs. The amount of training and proportion of full time workers are positively correlated with capacity utilization. Future research should focus on training and full time workers in operationalizing workforce characteristics in ICT productivity studies. Once again, the correlations were small.

The correlations did not confirm the relevance of female participation, despite hints from the descriptive analyses. The results show no significant correlations between the gender variables and productivity. It is important to note the correlations show bivariate relationships and do not demonstrate how each variable vary with productivity in the context of other variables. While the

correlations did not support the descriptive analyses findings of possible impact of female participation on capacity utilization, it would be worthwhile to pursue further investigations of female participation in the workforce, ICTs, and capacity utilization to investigate stronger evidence.

Workforce and ICTs

Based on the exploratory analysis, the industries demonstrate an inability to fully leverage ICTs to increase capacity utilization, hence the impact of ICTs on capacity utilization is mixed (Sigala, 2003). ICTs alone do not appear to improve productivity but having a workforce capable of leveraging them is critical. The analysis points to the need for a stable and skilled workforce, capable of leveraging existing technology, and possibly higher female participation in the firm at any level. This requires managers to challenge the notion about the reluctance to hire female workers for IT jobs (Tabuwe et al., 2013).

Unanswered questions remain on women use of ICTs and productivity ((Hilbert, 2011) and the important role of women in using technology (Paetz, 2011). It is no surprise the benefits of ICTs could be realized with a capable workforce. The correlation analysis provides support for this view. It indicates companies with international certifications are better prepared to improve performance and compete with industry rivals. This is evidence that ISO 9000, Six Sigma, and other certifications help companies to perform better (British Standards Institute, 2016). A primary objective of certifications is to improve performance in quality, reliability, customer satisfaction, and efficiency. Certifications imply higher technology sophistication, which demands a higher skilled workforce. Certifications foster more formal training so it is expected that firms that invest in formal training improve their capacity utilization. It is no surprise better skilled and knowledgeable employees are more productive, resulting in increased capacity utilization.

Based on the descriptive analyses, we propose the following research directive to support further analysis. There may be a strong relationship between workforce capabilities and productivity. However, it is unclear whether technology sophistication, through the use and leverage of ICTs, is a by-product of effective use and leverage of ICTs or a corresponding facilitator of productivity. The role of female participation, although possibly similar across all levels of the

firm, remains questionable. Predictive analyses can also test the relationship between workforce capabilities and productivity using ICTs as control variables.

Gender and Productivity

The descriptive analyses provided a mixed picture regarding female participation in management and workforce, with respect to technology sophistication and capacity utilization. However, Figure 3 provided some hints because female participation from 2010 to 2014, mirrored capacity utilization, suggesting there may be a positive relationship. Also, in Figure 4, as female participation increased, so did capacity utilization for Eastern Europe, East Asia, and Southeast Asia. Based on Figure 3, changes in technology sophistication coincide with changes in female participation and management from 2006 to 2012. In addition, technology sophistication seems to mirror the average capacity utilization from 2006 to 2014. This is true for female participation and average capacity utilization from 2006 to 2012; after which female participation seemed to be out of sync with capacity utilization, and to a lesser extent technology sophistication. It is important to note that trends in technology sophistication and workforce training appear to be in tandem with capacity utilization (Figure 2). Furthermore, the regional comparisons in Figure 4 suggest the impact of female participation may be similar across different levels of the firm, and that cultural differences may play a role in influencing the impact. In summary, while the picture is not abundantly clear, there are hints that technology and female participation may play a role in productivity.

In addition, the literature on gender and ICTs accounts for individual differences across gender and computer experience (Sagi et al., 2004). Previous discussions suggest that skills and training influence worker productivity regardless of gender. Therefore, we may consider investigating how intra-gender differences affect capacity utilization. For example, skilled versus unskilled, trained versus untrained, management versus non-management employees, are logical areas to investigate. We believe females in a productive workforce are better able to motivate and change negative female attitudes towards the use of ICTs and hiring females. Is it possible that female employees play an important management role in companies by advocating training, regardless of gender?

Following the discussion, we propose the second research directive to support further analysis: It would be useful to further explore relationships between female participation, ICTs and productivity by using training, culture, and ICTs as control variables.

Implications for Industry

Industry level research benefits institutions, industries, and economies. Institutions are better able to negotiate industry competition by better positioning themselves to deal with it. Understanding helps industries attract more players to the market and governments are better able to set the economic tone to enable fair competition, trade, legislation, and business incentives.

Based on our investigation, companies could benefit from knowing if all international certifications lead to better capacity utilization. They could benefit from knowing which certifications are better suited for improving capacity utilization. If certifications lead to increased productivity, industries and governments may provide incentives to encourage their use. If permanent employees, and formal training are correlated with capacity utilization, then companies may consider investing more in training and retention. Governments may provide economic incentives and training programs to aid the process. Understanding female representation in top management and the workforce, may inform management and economic decisions.

There is a reluctance to hire female employees to fill skilled IT positions for fear their family obligations would reduce productivity (Tabuwe et al., 2013). Assumptions about which IT jobs are appropriate for men and women (Ng & Mitter, 2005) exist, but our findings suggest a capable workforce that includes female employees, can improve productivity. It seems beneficial to determine the optimum gender mix of permanent female employees to hire, to optimize capacity. This can be determined with further investigation based on the directions laid out in this study.

Limitations and Future Research

We recognize several limitations of the study. A key limitation is the dataset. The five ICT variables used in the study may not capture the full spectrum of technology sophistication. The use of websites and email are increasingly becoming widespread by today's standards and may not reflect the current state of technological sophistication of a firm. The use of social media and other forms of ICTs were not captured in the survey. Based on research directives outlined in

Sections 5.1 and 5.2, future investigations could expand the five ICT variables to comprehensively capture technology sophistication.

Another limitation is the lack of clarity in the literature on how best to compute workforce, gender and ICT variables to analyze their impact on productivity. Multivariate relationships could be used to explore the relationships among variables. Without sufficient understanding of these relationships and research directives, modeling efforts may be futile. The exploratory analyses led to two broad research directives, which can be used to develop predictive models for further investigation. Unanswered questions about the role of female participation in the manufacturing workforce would advance the discussion on capacity utilization, and lead to more conclusive evidence regarding training, ICTs, and gender.

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