Economics Bulletin

Volume 34, Issue 4

Adoption of Information and Communication Technologies and New Organizational Practices in the Tunisian Manufacturing Sector

Adel Ben youssef
GREDEG-CNRS & Université de Nice Sophia-Antipolis

Walid Hadhri
UAQUAP-ISG Tunis (University of Tunis)

Hatem Mhenni
ESC Manouba (University of Manouba) Tunisia

Abstract

The aim of this paper is to explore the relationship between the adoption of Information Technologies(IT) and the adoption of New Organizational Practices (NOP) in the context of an emerging country (Tunisia). Based on a face-to-face questionnaire administrated to a random sample of 175 Tunisian manufactures we use ordered logit model to show a significant link between IT adoption and NOP. We show that the complementarity is strengthened when the technology evolves. Adoption and usage of latest technologies are pushed by the prior adoption of NOP

Citation: Adel Ben youssef and Walid Hadhri and Hatem Mhenni, (2014) "Adoption of Information and Communication Technologies and New Organizational Practices in the Tunisian Manufacturing Sector", *Economics Bulletin*, Vol. 34 No. 4 pp. 2237-2252.
Contact: Adel Ben youssef - adel.ben-youssef@unice.fr, Walid Hadhri - walid.hadhri@gmail.com, Hatem Mhenni - hatem_mhenni@yahoo.fr.
Submitted: May 24, 2014. **Published:** October 24, 2014.

1. Introduction

The economics literature has emphasized how prior IT investments and new forms of workplace organization may be complementary with investments in IT (Brynjolfsson and Milgrom, 2013). According to this literature, weak or lack of performance within firms that have invested in ICT is directly related to the lack or weak adoption of the complementary NOP especially in the emerging countries context[1].

Generally, two types of conjectures were formulated concerning the behaviour of companies in emerging countries with regard to the adoption and diffusion of IT and NOP. The first relates to the uncoordinated behaviours of adoption of the IT and NOP in emerging countries due to structural weakness of management and of governance of firms. This situation leads to the absence of complementarities between IT and NOP and weak global effect on performance. In some cases this anarchistic adoption process may lead to an internal "disorganization" of the firms and to a decrease of their structural competitiveness (Knights and Vudurbakis, 2005).

The second conjecture supposes fast adoption of organizational and technological change dictated by the markets forces (requirement of competitiveness). In spite of their context firms are rather reactive and adopt rapidly new technologies and practices. Complementary adoption pushed by the market forces improves their performance. This is particularly true for firms operating in an international setting and which are export-oriented (Arvanitis, 2004).

Our article contributes to this line of research and demonstrates that firms operating in open emerging economies are reactive to both technological and organizational changes via their international leakages. Adoption of IT and NOP is more related to market dynamics (external environment) than to internal environment (specificities of the given countries). Using a unique questionnaire run in 2004 for 175 firms, we show using an ordered logit model that in an earlier stage of IT and NOP adoption there was strong complementary in the adoption process. We will not explore the effects on performances and focus only on the link between the adoption and intensity of use of IT and NOP.

[1] India (Lal, 1999); Nigeria (Apulu and Latham, 2011; Lal, 2007); Tunisia (Ben Youssef et al. 2011); Pakistan (Mughal and Diawara, 2011); Malaysia (Alam & Noor, 2009).

Our article presents two originalities. First, we investigate the complementarities between IT and NOP by considering three waves of technologies. We make the difference between the technologies based on their age and purpose. We show that the complementarity is a matter of the last waves of IT and less the first waves. Second, we show that the complementarity between IT and NOP adoption occurs in earlier stage of adoption of IT.

The paper is structured as follows. Section 2 surveys the related theoretical and empirical literature focused on the complementarity between IT and NOP. Section 3 presents the sample's characteristics and our econometric methodology. Section 4 discusses the results and section 5 concludes.

2. Literature Review

Three alternative research strategies were used in order to show such complementarities. The first one consists in examining the correlations between productivity, investment in IT and NPO through an approach by the production function (Bresnahan et al. (2002), Caroli and Van Reenen (2001). The organization is approached as a sum of dummy variables showing if the new organizational practice exists or not within the firm. This research strategy examines if links exist rather than to show by which mechanisms go through (Black and Lynch, 2004; Bloom and al., 2013; Brynjolfsson and Hitt, 2000; Caroli and Van Reenen, 2001, Ben Youssef and al., 2011, Ben Youssef et al. 2012,).

The second strategy used by Ichniowski and al. (1997), Athey and Stern (1998) and formalized by Greenan and Mairesse (2004) consists to use varied and multiple information on the evolution of computerization and the organization within firms and to assess the complementarities in a dynamic way. Specific indicators showing the nature of the change between two periods reveal the complementarity.

The third strategy consists in an indirect approach (Brynjolfsson and Hitt, 2003). The authors measure the evolution of the data-processing capital through time (6 to 8 years). This time coincides with life period of computer equipment. Their observations tend to show that the longer time of adoption of the material is, the more the impact on the productivity is high. This impact is revealed by the elasticity of the IT capital on production. Their explanation lies in the fact that, behind this observation, the factor organization hides. The improvement of the productivity would be related to the fact that the firms once they invested in IT adopt organisational practices. The two actions would be sequential and related one to the other.

The optimal combination between the two factors requires time. The longer time is and the more the firms reach a high degree of effectiveness.

We aim at contributing to this research line and to challenge the last research strategy. We advocate that the complementarity between the adoption of IT and adoption of NOP may be revealed by the difference in the extent of the link between different generations of IT and NOP. We show that the complementarity is strengthened when the technology evolves. Adoption and usage of latest technologies are pushed by the prior adoption of NOP.

3. Data and empirical method

3.1. Data

The data for this study were gathered by a face-to-face questionnaire administrated to a random sample of industrial firms in Tunis, the largest metropolitan cities in Tunisia during the period from June 2004 to February 2005.[2] Out of 320 administrated surveys, 205 were partially or totally completed. However, only 175 usable surveys were retained for the data analysis because they were totally completed and free from any contradictions, providing a response rate of nearly 55%. The high response rate is a common fact in Tunisia as the Tunisian legislation obligates firms to respond to such type of surveys and the face-to-face procedure also helped to reach such level of response. Necessary conditions to insure the success of such a survey as well as its comparability with what is practiced in other countries were respected, in particular regarding training of interviewers and the test period. All respondents were chosen from the top management staff and all responses were treated with confidentiality.

Our sample has all the characteristics that make it an ideal candidate to represent the central nucleolus of stable and viable Tunisian firms. As we shall see below, there are no size and industry specific "traits" that would make it difficult to generalise our results.[3] This characteristic makes our study interesting when it comes to investigating IT adoption and usage in the majority of Tunisian firms (and, to some extent, of South Mediterranean firms) regions, and not only in the most advanced ones. Appendix 1, gives more details about the sample and its composition.

[2] The whole number of industrial firms with more than 10 employees in Tunisia (about 5600 firms) is stable. More than 30% of these firms are partially or totally owned by foreign investors.
[3] Unfortunately the used survey did not include questions concerning ownership issue.

Ben Youssef et al. (2011) identified three waves of IT using the same database. All indicators (adoption level of IT[4], depth of usage of IT[5] and time required to use particular IT[6]) show up that there are three waves: The first wave is called "general used technologies" assumed to be relatively widespread (more than 80%), intensively used (between 4 and 5 on Likert scale) and rapidly introduced in all business sectors. These technologies are: fixed phones, telecopy, office, computers and general purpose software. The second wave is formed by "intermediary technologies" with high potential of use. In the mid of the nineties they were named « new » IT: Internet, E-mail, specific software, free software, and mobile phones. The third wave is based on networking technologies. They are among the latest technological generations of IT. Most of them need to optimize their use, costly investment, know-how, and qualified human resources. These technologies are Intranet, laptops, videoconference (VC) and Electronic Data Interchange (EDI). All firms use the technologies of the first wave. We focused on the second and third waves of these technologies.

Thus, in order to highlight the depth of adoption of IT and its main determinants, we discriminate between these waves of technologies and focus only on the second and third.

3.2. Empirical method

In order to study the relationship between IT adoption and usage and their determinants we use an ordered logit econometric model. The aim of the model is to determine the effect of a given factor on the probability of the IT adoption and use by the firm. This method makes it possible to study the impacts of different factors on a multinomial ordered variable. This method is widely used nowadays for similar studies (Bocquet and Brossard, 2007).

Starting from these assumptions, we use the ordered logit models[7]. The explained variable is subscripted from 0 to 9 for the total adoption's score. These variables are thus discrete and ordinate. A logit multinomial model would thus neglect the ordinality of the dependent variable while a linear regression, on an opposite sense, would treat the difference between

[4] Estimated by the percentage of firms using each technology
[5] Evaluated by the average score of intensity of use indicated by respondents for each technology (likert scale)
[6] Calculated by the time gap between the creation date of the firm and the first use of each technology
[7] The basic variables of our study are binary and qualitative. Firms' answers give us the information on whether they adopt a particular technology or not. For example, a firm indicates if it chooses the adoption of Intranet or not. Since we have various types of binary variables, they are gathered, then, in different types of scores, in order to formulate a total score of IT adoption. This gives us the multinomial character of this distribution (because it is composed of various methods) and the ordered character (because it is deduced starting from other binary variables).

indices 3 and 4 in the same way that it treats the difference between indices 1 and 2, whereas this corresponds only to one classification. In these two cases, the estimators would be thus biased (Greene 2000; Thomas, 2000). Following this method, it's possible to study the influence exerted by series of factors on a multinomial ordered variable (Greene, 2000; Thomas, 2000).

Data were analysed using multiple regression analysis with a stepwise procedure used to determine the relative importance of a set of independent variables in determining the firm's intensity of IT use score. The data were analysed using SPSS 19.0, to the principal component analysis, and STATA, v. 11.0, to the estimation of the models. The data were examined for violation of the assumptions underlying multivariate methods prior to the analysis.

3.3. Definitions of the variables

3.3.1. Dependent variables

In our study we considered two models for two different dependant variables. Our dependent variables are obtained starting from the calculation of a total score of ICT adoption and a score of ICT usage for the second and third wave as defined above.

Intensity of ICT adoption

Our data describe five types of IT adopted by firms for the second wave and four types for the third wave. All IT variables are binary, in which value '0' means that the respondents were asked whether their firm had adopted the considered technology and value'1' that it is adopted. Thus, every firm has a score between 0 and 5 for the second wave and between 0 and 4 for the third wave. The variable used here is an ordered multinomial variable characterizing the adoption of the IT (score of adoption). We obtain two IT adoption score: IT adoption score (wave2) and IT adoption score (Wave3).

Intensity of IT use

Firms were asked to classify themselves, on a 5 points ordinal scale, according to the answer[8] that best described their intensity of usage of IT tools. The IT tools list included the tools listed above for Wave 2 and Wave 3. The weighted values were added across all IT tools listed to yield a total intensity of IT use score. Higher scores represent more intense use.

[8] The answers were weighted as (1) null, (2) weak, (3) average (4) important, (5) very important.

3.3.2. Explanatory variables

The aim of our estimation is to characterize the adoption and usage of IT by looking at two explanatory factors: characteristics of the firm and NOP.

characteristics of the firm

Five explanatory factors impacting new technology adoption were highlighted by empirical literature: size of the firm, firm's seniority, adoption time, employees' skills and, firm's web site[9].

Size of the firm: is a variable with four response levels which measures a firm's size (from '0' if the firm has less than 25 employees to '3' if it has more than 100).

Firm's seniority: is a variable with four response levels which measures the "Firm Age" (from '0' if the firm aged less than 2 years to '3' if it aged more than 100 years).

Adoption time: it represents time since first adoption of IT tools. This variable summarizes the speed of adoption of the IT tools.

Web Site: is a dummy variable, which equals 1 if the firm has a Web site in 2005 and 0 if not.

Employees' skills: is a variable that measures the skilled labour intensity. It represents share of qualified employees (managers and high qualified personnel in the administrative and technical departments) over the total number of employees.

There are also other important factors (variables) that could influence the decision of IT adoption such as belonging to a group and whether the firm is domestic or multinational. Unfortunately, these variables were not available in our database.

New Organisational Practices (NOP)

Four groups of NOP are considered:

1- *Work Organization*: comprises Work by project, Modular work and 5S method

[9] There are also other important factors that could influence the decision of IT adoption such as belonging to a group and whether the firm is national or multinational. Unfortunately, these variables are not available in our database.

2- *Quality approach*: comprises ISO certification and Total Quality management (TQM);

3- *Internal contractual arrangement*: including organization in profit center, internal control, etc…;

4- *External contractual arrangement*: including the just in time delivery system and just in time process system.

These four groups are all binary, in which value '0' means that the respondents were asked whether their firm had adopted the considered practice and value'1' that it is adopted.

4. Results and discussion

This section presents and discusses the results.

The estimates obtained in the case of the discrete variables are shown in Table 1. By observing all the explanatory variables, it can be outlined that almost all variables (except for those related to external contractual arrangement) has a statistically significant effect on the adoption and use of IT and our results confirm most of the theoretical expected effects.

Table 1 Determinants of IT Adoption and Intensity of Usages

Explanatory Variables	**IT adoption**		**Intensity of IT use**	
	Wave 2	***Wave 3***	***Wave 2***	***Wave 3***
	Odds Ratios[10]	***Odds Ratios***	***Coef.***	***Coef.***
A. Internal characteristics of the firm				
Firm size				
- 5 to 25	Ref.	Ref.	Ref.	Ref.
- 25 to 50	3.5639***	1.8222	1.9554*	0.2967
- 50 to 100	3.9255***	9.0887***	2.1854**	0.9710*
- more than 100	15.209***	23.515***	3.6745***	2.3588***
Firm Age				
- less than 2 years	Ref.	Ref.	Ref.	Ref.
- 2 to 5 years	2.6341	1.7157	3.4157*	0.2982
- 5 à 10 years	16.975***	1.3011	7.3643***	0.9524
- more than 10 years	8.9705***	2.7510	6.8564***	1.0788
Adoption time	60.750***	8.2459**	4.4824	2.5342**

[10] Odds Ratio>1(respectively Odds Ratio<1) suggests that dependent variable are positively (respectively negatively) associated with the explanotry variable.

Web site	- No	Ref.	Ref.	Ref.	Ref.
	- Yes	1.0715	9.0987***	0.9997	1.9357***
Employees' skills		19.978**	22.183***	3.8659*	2.8516**
B. New Organizational Practices					
Org grp1	- No	Ref.	Ref.	Ref.	Ref.
	- Yes	1.2374	2.7163**	0.8421	1.1289***
Org grp2	- No	Ref.	Ref.	Ref.	Ref.
	- Yes	1.3750	3.2379***	1.5062**	0.8466**
Org grp3	- No	Ref.	Ref.	Ref.	Ref.
	- Yes	3.0349***	0.8722	1.8082**	0.8185*
Org grp4	- No	Ref.	Ref.	Ref.	Ref.
	- Yes	0.6035	1.9062	-1.0180	0.8896**
Constant		-	-	4.8911**	2.9441***

*: Significant at 10%, **: Significant at 5%, ***: Significant at 1%
IT adoption Model results are presented as odds ratios

Characteristics of the firm and patterns of adoption of IT

Firstly, our work confirms the rank effect discussed by Karshenas and Stoneman (1993), which has also been established by Bartoloni and Baussola (2001). We found that firms' adoption and use of IT is a positive function of their size. As it was expected, there is a positive correlation between firm's size and IT capital stock (adoption), showing the existence of scale economies for digital investment. Larger firms are more likely to adopt digital technologies because they show lower levels of financial coordination tools (wave 2 and 3).

Secondly, concerning firm's seniority effect, we show that IT adoption and uses differ according to the models. Thus, the seniority of the firm has a more significant and positive effect on the adoption and the usage of the second wave IT then the third. On the other hand, the effect of this variable in the intensity of use's case is more important for aged firms than for the others. Within our sample and especially for the companies that are older than ten years we find a significant effect.

Thirdly, the adoption time variable is significant to explain the adoption and the depth of adoption of IT. We had defined this variable as the speed of adoption of each technology by individual firm that is the inverse of the time taken by each firm to adopt a new technology. The correlation between the two variables indicates that a propagation effect exist and

confirm our first intuition that the intra-firm hypotheses are suitable to descript the adoption phenomena. However, the relation between adoption time and IT adoption is nonlinear, as the effect of the variable "adoption time" on IT adoption increases but remains less than proportionally. Further estimation results, reported in Appendix 2, confirm this non-linearity, as the sign of the square of the variable "Adoption time" is negative and statistically significant. We conclude that the IT adoption may be an increasing but following a concave function.

Moreover, when we look at the variable "having a website", we find that the relation is significant with adoption and use of third waves' IT. However, this effect is not significant for the IT tools second wave. Our findings suggest that the contagion dynamics are working and the epidemic effect is confirmed (Hollenstein, 2004).

Finally, we find that firms that have more qualified personnel are those whose adoption and use of IT are more important. This result is important for the use and adoption of IT tools in the third wave. Thus, IT tools of the third wave require more skilled employees. These findings are supported by previous studies that also demonstrate a positive correlation between IT uses and workers skills (Bresnahan et al., 2002, Arvanitis and Loukis, 2009) and that investment in human capital is the main determinant of IT (Mughal and Diawara, 2011).

NOP, adoption and intensity of use of IT

Tables 1 and 2 shows that NOP have rather different effects on IT adoption and intensity of usage patterns.

Table 2: Scores of ICT adoption and usage: Summary Statistics

			Scores Adoption				**Score Usage**
	Number of firms	%	total	Groupe 1	Groupe 2	Groupe 3	Total
Size							
- 5 to 25	33	18.86	7.30	3.75	2.84	0.69	40.69
- 25 to 50	39	22.29	8.41	3.76	3.58	1.05	44.84
- 50 to 100	40	22.86	8.60	3.65	3.40	1.55	44.50
- more than 100	63	36.00	10.87	3.95	4.34	2.57	51.66
Age							
- less than 2 years	5	3.38	5.40	2.60	2.20	0.60	34.20
- 2 to 5 years	20	13.51	7.19	3.38	2.80	1.00	38.09
- 5 to 10 years	32	21.62	8.91	3.80	3.86	1.25	45.22
- + 10 years	91	61.49	9.72	3.93	3.84	1.93	48.92

New organizational practices							
1. Work Organization							
- Work by project	73	41.71	10.36	3.97	4.19	2.20	51.38
- Modular work	35	20.00	9.68	3.77	3.62	2.28	48.40
- 5 S method	46	26.29	10.58	3.97	4.28	2.32	52.34
2. Quality approach							
- ISO certification	59	33.71	11.08	3.89	4.38	2.79	53.30
- TQM	63	36.00	10.61	3.86	4.14	2.61	51.44
3. Internal contractualization							
- Center of profit	64	36.57	10.28	3.98	4.32	1.96	51.40
- Internal control	28	16.00	10.14	3.82	4.00	2.32	50.50
4. External Contractualization							
- Delivery system	56	32.00	9.69	3.89	3.73	2.07	48.33
- Production system	41	23.43	9.26	3.85	3.39	2.02	46.09
Total	175	100	9.13	3.80	3.68	1.64	46.44

Firstly, there are asymmetric effects between third and second generation of IT. While the probability of adoption and intensity of use of IT of third is positive and significant when firms adopt NOP (Org gr1). There is no relation between adoption and Intensity of use of IT of second generation of IT and the adoption of NOP (Org gr1). The newest generation of IT are more likely to be adopted and to complement NOP. The latter comer effect is holding.

Secondly, table 3 shows also that NOP (Org gr2) quality management system is strongly related to intensity of usage of IT whether it is second or third generation of IT. However, only the adoption of third generation of IT is linked to NOP (Org gr2). Quality management systems involve an intensive usage of IT. The latest generations of IT seems more appropriate to this kind of NOP allowing better coordination of the entire quality processes. This is in line with the work of Foss et al. (2007), which demonstrated that the interaction among decision-makers and executives are creating less hierarchical structures.

Thirdly, our results show also that NOP (Org gr3) internal contractualization system is strongly related to intensity of usage of IT whether it is second or third generation of IT. However, these NOP are linked to the adoption to the second generation of IT and not to the third generation of IT. This kind of NOP seems does less intensively need coordination between team members (Forman and Goldfarb, 2006). This result is related to the one obtained by Martin (2011) ICT usage increases the development of a team spirit between workers.

Fourthly, our results show that the adoption of IT (whether is second or third generation) is not linked to NOP (Org gr4) external contractual arrangement. However, intensity of usage of third IT generation is weakly linked to NOP (Org gr4) external contractual arrangement. This weak effect may be explained by weak adoption of IT of external partners (clients, sub-contractors...), especially second generation. However an intensive usage of third generation of IT is linked to the adoption of NOP (Org gr4).

Overall, our results confirm that in an earlier stage of adoption of these technologies, the adoption of NOP by Tunisian firms have pushed them to adopted and use the latest wave of technology. The complementarity between the adoption of IT and adoption of NOP is revealed by the difference in the extent of the link between second and third generation of IT. While it is expected that the latest IT are less adopted and used. We show that prior adoption of NOP pushed Tunisian firms to better use and adopt the third wave of technologies.

5. Conclusion

The central proposition of this study is that the intensity of use of the latest information technologies (at that moment of time) is closely linked to the adoption of NOP of Tunisian firms. Our findings confirm the theoretical conjecture according to which market forces rather than time push firms even in an emergent country (Tunisia) to adopt NOP and IT.

In sum, investing in new IT-based production machinery changes not only the quantity of that input and related inputs, but it also changes a business's competitive strategy as well as the work practices and skill requirements of the workforce needed to implement the new strategy. International subcontracting and the insertion of the Tunisian firms in the international market directly pushed adoption of the NPO. This way of adoption of NPO preceded the computerization and the use of IT.

In terms of policy implications, the above findings suggest both the use of IT (of latest generation of technologies) and NOP will need to increase the skills of the employees. Increasing the productivity of emergent economies firms will need huge investment in human capital. Otherwise, the process will be constrained. Upgrading human capital within emergent countries SMEs needs to build an absorptive capacity in matter of IT. It can be achieved by lowering, through different types of policy instruments, the hiring and training costs of educated workers, and especially university graduates.

References

Alam, S. S., and M. K. M. Noor (2009) "ICT adoption in small and medium enterprises: An empirical evidence of service sectors in Malaysia" *International Journal of Business and Management*, 4(2), 112–125.

Apulu, I., and A. Latham (2011) "Drivers for information and communication technology adoption: A case study of Nigerian small and medium sized enterprises" Canadian Center of Science and Education. *International Journal of Business and Management*, Vol. 6, No. 5.

Arvanitis, S. (2004). "Information technology, workplace organization, human capital and firm productivity: evidence for the Swiss economy" In OECD (2004) *The Economic Impact of ICT – Measurement, Evidence and Implications*, OECD, Paris.

Arvanitis, S. and E. Loukis (2009) "Information and Communication Technologies, Human Capital, Workplace Organization and Labour Productivity in Greece and Switzerland: A Comparative Study Based on Firm-level Data" *Information Economics and Policy*, 21, 43-61.

Athey, S. and S. Stern (1998) "An Empirical Framework for Testing Theories About Complimentarity in Organizational Design" NBER Working Papers 6600, National Bureau of Economic Research, Inc.

Bartoloni E. and M. Baussola (2001) "The Determinants of Technology Adoption in Italian Manufacturing Industries", *Review of Industrial Organization*, November 2001, Volume 19, Issue 3, pp 305-328

Ben Youssef, A., W. Hadhri and H. M'Henni (2011) "Intra-firm diffusion of innovation: Evidence from Tunisian SME's in matter of Information and Communication Technologies", *Middle East Development Journal* (MEDJ) Volume: 3, Issue: 1(2011) pp. 75-97.

Ben Youssef, A., D. Castillo-Merino, W. Hadhri (2012) "Adoption and Usage of ICT by Catalan Firms", in Internet Econometrics, New Palgrave MacMillan, Allegrezza & Dubrocard (ed). Pp. 288-308. Chapter 8.

Bloom, N., L. Garicano, R. Sadun and J. Van Reenen (2013) "The distinct effects of Information Technology and Communication Technology on firm organization" *CEPR Discussion Papers 9762*, C.E.P.R. Discussion Papers.

Bocquet, R. and O. Brossard (2007) "The variety of ICT adopters in the intra-firm diffusion process: Theoretical arguments and empirical evidence" *Structural Change and Economic Dynamics* 18, pp: 409–437.

Bresnahan, T., E. Brynjolfsson and L. Hitt (2002) "Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-Level Evidence" *The Quarterly Journal of Economics*, vol. 117, n° 1, pp. 339-376.

Brynjolfsson, E. and L. Hitt (2000). "Beyond Computation: Information Technology, Organizational Transformation and Business Performance". *Journal of Economic Perspectives.* Vol. 14, no. 4, pp 23-48.

Brynjolfsson, E. and L. Hitt (2003) "Computing Productivity: Firm-Level Evidence" *MIT Sloan Working Paper* No. 4210-01.

Brynjolfsson E. and P. Milgrom (2013) "Complementarity in Organizations" *in The Handbook for Organization Economics*, ed. Robert Gibbons and John Roberts. Princeton University Press.

Caroli, E. and J. Van Reenen (2001) "Skill-biased organizational change: evidence from a panel of British and French establishments" *Quarterly Journal of Economics*, CXVI(4), 1449–1492.

Crespi, G., C. Criscuolo and J. Haskel (2007) "Information technology, organizational change and productivity growth: Evidence from UK firms" CEP discussion paper, no.783.

Forman, C. and A. Goldfarb (2006) "*Diffusion of information and communication technologies to businesses*" Handbook of Economics and Information Systems, Terry Hendershott, ed., Elsevier, 2006

Foss, K., N. J. Foss and P. G. Klein (2007) "Original and Derived Judgment: An Entrepreneurial Theory of Economic Organization" *Organization Studies*, 28(12), 1893-1912.

Greene, W.H. (2000) "*Econometric Analysis*" Fourth Edition, Prentice International Hall Edition.

Greenan and Mairesse (2004) "A Firm Level Investigation of the Complementarity between Information and Communication Technologies and New Organizational Practices". In *Annual Conference of the Western Economic Association.* June 29-July 3, 2004: Vancouver, Canada.

Hollenstein, H. (2004) "The determinants of the adoption of information and communication technologies (ICT). An empirical analysis based on firm-level data for the Swiss business sector" *Structural Change and Economic Dynamics* 15, 315–342.

Ichniowski C, Shaw K, Prennushi G. (1997) The effects of human resource management practices on productivity: a study of steel finishing lines. *American Economic Review*, 87(3):291–313.

Karshenas M. and Paul L. Stoneman (1993) "Rank, Stock, Order, and Epidemic Effects in the Diffusion of New Process Technologies: An Empirical Model", *The RAND Journal of Economics*, Vol. 24, No. 4 (Winter, 1993), pp. 503-528.

Knights D., Vudurbakis T., (2005) "Information technology as organization/disorganization", *Information and Organization*, vol. 15, pp. 181-184.

Lal, K., (1999) "Determinants of the adoption of information technology: a case study of electrical and electronic goods manufacturing firms in India" *Research Policy*, 28, 667–680.

Lal, K. (2007) "Globalization and adoption of ICTs in Nigerian SMEs" *Science, Technology Society*, 12(2), 217–244.

Lucchetti, R. and A. Sterlacchini (2004) "The Adoption of ICT among SMEs: Evidence from an Italian Survey" *Small Business Economics, Springer*, vol. 23(2), pages 151-168, 09.

Machikita, T., M. Tsuji and Y. Ueki (2010) "How ICTs raise manufacturing performance: Firm-level evidence in Southeast Asia" *Economic Research Institute for ASEAN and East Asia papers* DP-2010-07.

Martin, L. (2011) "The effects of ICT use on employee's motivations: an empirical evaluation" *Economics Bulletin*, Vol. 31no.2 pp. 1592-1605.

Mughal, M. and B. Diawara (2011) "Human capital and the adoption of information and communications technologies: Evidence from investment climate survey of Pakistan" Kiel Institute for the World Economy Economics Discussion Papers, No 2011–21.

Thomas, A. (2000) "*Econometric of the qualitative variables*" Dunod, Paris.

Thong, J.Y.L. (1999) "An Integrated Model of Information Systems Adoption in Small Business" *Journal of Management Information Systems*, 4(15), pp.187-214.

Appendix 1: Sample distribution by firm size and industry

Industry Size	Clothing & Footwear	Chemicals and Plastic Products	Mechanical & Electrical Equipment	Food & Beverages	Total
5 to 24	6.45	32.35	35.90	10.00	18.86
25 to 49	16.13	41.18	30.77	7.50	22.29
50 to 99	33.87	17.65	15.38	17.50	22.86
>100	43.55	8.82	17.95	65.00	36.00
Total	35.43	19.43	22.29	22.86	100

Appendix 2 Determinants of IT Adoption and Intensity of Usages

Explanatory Variables	**IT adoption**		**Intensity of IT use**	
	Wave 2	***Wave 3***	***Wave 2***	***Wave 3***
	Odds Ratios	***Odds Ratios***	***Coef.***	***Coef.***
A. Internal characteristics of the firm				
Firm size				
- 5 to 25	Ref.	Ref.	Ref.	Ref.
- 25 to 50	3.7093***	1.9715	1.9644*	0.3579
- 50 to 100	4.4553***	9.6202***	2.2100**	1.1395*
- more than 100	16.344***	29.982***	3.7126***	2.4888***
Firm Age				
- less than 2 years	Ref.	Ref.	Ref.	Ref.
- 2 to 5 years	3.7621	2.1435	3.2989	0.2692
- 5 à 10 years	13.840***	1.7916	7.3972***	1.3281
- more than 10 years	8.0898**	3.1795	6.9147***	1.6836*
Adoption time				
Time	206.02*	160.54*	9.8429	8.2812*
$(Time)^2$	0.0005**	0.0053*	-6.6868	-11.904**
Web site				
- No	Ref.	Ref.	Ref.	Ref.
- Yes	1.0994	9.2197***	0.9396	1.7689***
Skills	15.604**	21.407***	4.0448*	3.2855***
B. New Organizational Practices				
Org grp1				
- No	Ref.	Ref.	Ref.	Ref.
- Yes	1.0818	2.4967**	0.8561	1.0999**
Org grp2				
- No	Ref.	Ref.	Ref.	Ref.
- Yes	1.4453	3.3898***	1.5090**	0.8744**
Org grp3				
- No	Ref.	Ref.	Ref.	Ref.
- Yes	3.5946***	0.8599	1.8232**	1.0154**
Org grp4				
- No	Ref.	Ref.	Ref.	Ref.
- Yes	0.6654	1.9267	-0.9886	.9163**
Constant	-	-	4.1924*	3.0433**

*: Significant at 10%, **: Significant at 5%, ***: Significant at 1%,
IT adoption Model results are presented as odds ratios