Adoption of cloud computing in emerging countries: the role of the absorptive capacity

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ABSTRACT

This paper aims to develop a theoretical framework that explains the cloud computing (CC) adoption decision in emerging countries. It emphasizes the specific role of technological absorptive capacity especially if CC is adopted to boost innovation. Our examination of absorptive capacity is in line with Todorova and Durisin (2007) who propose a framework linking the contributions of Cohen and Levinthal (1989) and Zahra and George (2002). To test our theoretical claims, we estimate two models predicting the probabilities of adopting CC, and of adopting CC for innovative aims. We include in our model variables for the firm's competitive pressure and external environment, perceived technological impacts, and technological absorptive capacity. We also include control variables such as firm age and size, and sector of activity. We employ a bivariate probit model to explain the determinants of the decision to adopt CC, and an ordered probit model with sample selection in order to understand the determinant of adoption for innovation. Our data are from a questionnaire administered face-to-face to a random sample of 350 Tunisian firms. Our empirical findings confirm our theoretical claims and show that perception of the technology is a key factor in CC adoption (for general purposes), and that absorptive capacity is fundamental for adoption of CC for innovation. We show also that competitive pressure is an important explanatory factor: the more competitors that adopt a technology, the more likely the firm will adopt it.

Keywords: Innovation, information and communication technologies, cloud computing, Heckman selection method, probit model, technology adoption, Tunisia, intellectual property rights, absorptive capacity.

JEL Classification: L21, O31, O33.

RÉSUMÉ

Cet article a pour objectif de développer un cadre théorique qui explique la décision d'adoption de l'information en nuage (Cloud Computing (CC)) dans les pays émergents. Il met l'accent sur le rôle spécifique de la capacité d'absorption technologique surtout lorsque la décision d'adoption a pour objectif de stimuler l'innovation. Pour se faire, nous adoptons une conception de la capacité d'absorption identique à celle développer par Todorova et Durisin (2007) qui proposent un cadre reliant les contributions de Cohen et Levinthal (1989) et Zahra et George (2002). Pour tester notre modèle théorique, nous estimons deux modèles économétriques relatifs à la probabilité d'adoption du CC en général et à la probabilité d'adoption du CC pour innover. Nos données proviennent d'un questionnaire administré en mode face-à-face sur un échantillon aléatoire de 350 entreprises tunisiennes. Nos résultats empiriques confirment nos affirmations théoriques et montrent que la perception de la technologie est un facteur clé d'adoption du CC (en général), et que la capacité d'absorption est fondamentale pour l'adoption du CC pour une finalité d'innovation. Nous montrons également que la pression concurrentielle est un facteur explicatif important.

Mots-clés : Innovation, technologies de l'information et de la communication, informatique en nuage, modèle de sélection de Heckman, adoption des technologies, droits de propriété intellectuelle, capacité d'absorption technologique.

INTRODUCTION

One of the most important differences between Developed Country (DC) firms and Emerging Country (EC) firms is their ability (on average) to innovate and to invest in the acquisition of new technologies. There may be several constraints to the ability of ECs to innovate and to adopt new technologies including lack of human capital, lack of financial resources, and weak science and technology system. However, EC firms' adoption of disruptive technologies can be faster than their earlier adoption by DC firms, because EC firms can exploit catching-up and leapfrogging tactics. EC firms seek opportunities to modernize their business and to improve their performance at lower cost.

Cloud Computing (CC) is a novel paradigm in computing and can be considered a disruptive technology[1] leading to paradigmatic changes both inside and outside the firm (Voas and Zhang, 2009; Marston *et al.*, 2011; Sultan, 2013). CC is defined as "*a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can rapidly provisioned and released with minimal management effort or service providers' interaction*" (Li *et al.*, 2011). CC is associated with an increase in the use of new software applications and solutions, and enables implementation of innovations at a price relative to their real benefits. For example, CC allows new sales management processes, new marketing channels, and access to new geographic markets, and increases collaboration with external partners.

From an analytical perspective, the adoption of CC as a new technology in the context of ECs involves two distinct strands in the literature.

The first strand explores the determinants of CC adoption in ECs. There is a fairly large literature showing how the classical determinants such as firm characteristics (firm size and age), the firm's environment (trading partners and competitive pressure), human factors (CIO innovativeness, IT skills), and technological factors (relative advantage and compatibility) are correlated with the CC adoption decision (Lumsden and Gutierrez, 2013; Alsanea and Wainwright, 2014; Gupta *et al.*, 2013; Tehrani, 2013). At the same time, several contributions highlight how several barriers such as bandwidth, mobility, fear of losing control, security, privacy, data protection, lack of CC business brokers, and unawareness which may lower the rate of adoption (Gréczy *et al.*, 2012; Oliveira *et al.*, 2014, Phaphoom *et al.*, 2015).

Most works analyze the decision to adopt CC without considering either the disruptive nature of the technology or the potential radical changes and their impact on the firm's internal organization. The adoption and use of CC tends to differ from the adoption and use of previous information technolo-

[1] A disruptive technology is a combination of existing and new technologies which can be used in innovative ways to change technological services or product paradigms (Ganguly *et al.*, 2010).

gies (IT) especially in the context of EC. According to Tiers *et al.* (2013), CC induces four complementary disruptions in the firm: technical disruption, market disruption, human disruption, and security disruption, and important changes to firm behavior. The adoption decision needs to take account of all these disruptive effects and can be evaluated negatively in the context of ECs. Moreover, this literature does not differentiate among the reasons for adopting CC and mostly overlook the specific role of absorptive capacity (ACAP).

The second literature strand points to the special role of technological absorptive capacity in IT adoption. Absorptive capacity (ACAP) is the capability to recognize the value of new knowledge, to assimilate the new knowledge, and to apply it for commercial ends. The concept of ACAP has been widely used in the context of innovation (Tsai, 2001; Meeus *et al.*, 2001) and in relation to IT (Boynton and Zmud, 1994; Ja-Shen Chen *et al.*, 2004; Harrington and Guimaraes, 2005). There is a vast body of work on the key role of absorptive capacity in the process of adoption of IT, but few studies of how the adoption of CC depends on existing technological ACAP and how it affects the firm's innovation activity.[2] There is some evidence that CC is increasing the propensity in EC firms to innovate and to adopt newer innovations at lower cost.

Understanding the link between the adoption of CC and the firm's internal organization is crucial in the context of ECs. Uncoordinated adoption of IT and organizational practices by EC firms can lead to lack of complementarities between IT and organizational practices, and an overall weak effect on firm performance due to structural weaknesses related to the firm's management and governance. In some cases, an anarchistic adoption process can lead to internal "disorganization" and a decrease in the firm's structural competitiveness (Knights and Vudurbakis, 2005). Thus, the adoption and use of CC tends to differ from previous adoption of IT. To our knowledge, few academic works propose an analytical framework for the adoption of CC in the context of ECs, and the specific role of absorptive capacity in the process of its adoption especially if innovation seeking.

This paper addresses these issues and develops a theoretical framework to explain the CC adoption decision in ECs. It emphasizes the specific role of technological ACAP especially when the firm is seeking to innovate by adopting CC. The concept of ACAP considered in this work is in line with Todorova and Durisin (2007) who propose a framework linking the contributions of Cohen and Levinthal (1989) and Zahra and George (2002).

Our methodological approach relies to similar works conducted by Tehrani (2013) and Phaphoom *et al.* (2015) and uses the probabilistic models in order to model the decision of adoption of CC. We test our theoretical predictions

[2] E.g., Xu (2012) shows that CC can facilitate cloud manufacturing and could change the boundaries between certain economic sectors.

based on data derived from a questionnaire administered face-to-face to a random sample of 350 Tunisian firms. We estimate two models predicting the probability of adopting CC for general purposes (especially to increase competitiveness) and adopting CC for innovative aims, taking account of competitive pressure and the firm's external environment, perceived technological impacts, and the firm's technological ACAP. We include control variables for firm size, sector of activity and age. We employ a bivariate probit model to analyze the determinants of the decision to adopt CC, and an ordered probit model with sample selection in order to understand the determinants of CC adoption for innovative aims.

The rest of the paper is structured as follows. Section 2 proposes our analytical framework and main hypotheses. Section 3 presents the sample and the econometric models. Section 4 discusses the econometric results and discusses some limitations of our study. Section 5 concludes.

2. ADOPTION OF CC IN EMERGING COUNTRIES: THE SPECIFIC ROLE OF FIRMS' TECHNOLOGICAL ABSORPTIVE CAPACITY

This section reviews the arguments for adopting CC, focusing especially on the motive of innovation in the context of ECs, formulates our main hypotheses and presents our proposed model.

Our analytical work relies on a Technology-Organization-Environment (TOE) framework which it extends by including the firm's ACAP as a main component of the firm's internal organization. Studies employing the TOE theoretical framework have explored how CC is adopted.[3] According to Baker (2011), there are three groups of factors affecting the adoption of technological innovations: Technological factors (perceived characteristics of the technological innovation), Organizational factors (internal firm characteristics) and Environmental factors (characteristics of the firm's external environment) ones. We suggest that these three components vary widely between the DC and the EC contexts.

2.1. Environment: competition pressure, Internet connection and CC adoption

The adoption of new technology is sensitive to the firm's interactions and external environment. The decision to adopt a new technology is encouraged by environmental pressure (DiMaggio and Powell, 1983). As the number of adopters increases the incentives for non-adopters to imitate their behavior also increase (Tolbert and Zucker, 1983).

[3] Alternative theories such as Technological Acceptance Model (TAM) or the Theory of Diffusion of Innovation (DOI) (Zhu *et al.*, 2006), can be used to explain CC adoption. But these analytical frameworks do not allow including the absorptive capacity since they are mostly focused on Technological and Human Factors.

The firm's external environment includes various physical characteristics such as public utilities provision, the local labor market, Internet connection quality, and value chain actors (competitors, sub-contractors, clients, customers, etc.). The external environment differs greatly between ECs and DCs. For example, the physical characteristics such as Internet connection, public utilities, etc. are of lower quality and less available. Also, it is generally acknowledged that EC markets are less competitive, that is, competition is less intense. All these differences have an impact on the decision to adopt CC.

Tiers *et al.* (2012) propose a framework for CC adoption. They consider that the adoption decision depends heavily on the external environment especially users and competitors. Therefore, competitive pressure is considered to be positively correlated to the adoption of CC (Lumsden and Gutierrez, 2013; Tiers *et al.*, 2013; Low *et al.*, 2011, Mohammed *et al.*, 2009). More generally, Pan and Jang (2008) suggest that pressure from business partners is a major determinant of the adoption and use of IT.

Most ECs are characterized by inefficiencies and coordination problems. CC can contribute to resolving these problems and improving the entire economic system. Low *et al.* (2011) highlight the advantages of CC adoption in the context of ECs pointing out that it improves the speed of business communications, resolves coordination problems among firms, improves communication with customers and facilitates access to market information. CC allows the sharing of common applications and hardware. It can promote the creation of new products and services, and increase the efficiency of networks (productive system), increase added value and allow the sharing of common inputs. CC can foster "interactive learning" (Lundvall, 1988; Meeus *et al.*, 2001) and contribute to solving coordination problems in ECs.

In relation to the firm's physical environment, the literature mostly agrees that the main problem preventing the adoption of CC in the context of ECs is Internet bandwidth and telecommunication infrastructure. CC is an attractive service if and only if the speed of the Internet guarantees effective use. ECs are not a homogeneous group. In many ECs Internet connection and Internet services are close to DCs standards; in others, the Internet connection is lower quality. Based on those considerations we test two main hypotheses:

H 1a: Competitive pressure stimulates CC adoption in ECs.

H 1b: Internet connection quality affects the CC adoption decision.

2.2. Technology: perception of CC and its adoption

Perception of the technology is widely supposed to be a key driver of the adoption of innovations and new technologies. Several papers show that the perceived advantages and disadvantages of CC can differ substantially between ECs and DCs (Phaphoom *et al.*, 2015; Trivedi, 2013; Morgan and Conboy, 2013, Grobauer *et al.*, 2011). This is due mainly to the profiles of managers and differences in the intensity of competition between ECs and DCs.

CC is associated with several economic advantages which are discussed extensively in the literature. Firstly, CC allows firms to customize their IT services to their specific needs, and thus, to cut costs. Most academic studies discuss the conditions under which the cost-cutting argument can be considered the main driver of adoption (Armbrust *et al.*, 2010; Marston *et al.*, 2011; Rafique *et al.*, 2010). Secondly, CC improves the firm's IT capacity. IT provides greater capacity without the need for more investment in computing infrastructure, memory and storage capacity (no need for dedicated servers). Firms benefit from flexible and quasi-infinite storage space and greater elasticity based on the technical capabilities (data processing speed) of the remote hosts used for CC. Thirdly, CC provides a lower cost service based on pay per use consumption which optimizes the firm's management costs and make related spending on CC an operating expense. The price of the service is calculated based on the firm's effective consumption - similar to charging for gas or electricity consumption. To an extent the firm buys the possibility of data-processing power on demand. Pooling hardware resources optimizes costs compared to having these services delivered. Fourthly, firms obtain access to various applications such as customer relationship management packages, without having to acquire the corresponding licenses. The firm can explore new technological possibilities such as e-commerce, in order to improve its efficiency and innovativeness at reasonable cost.

There is a large and important literature stressing that despite the benefits the perceived advantages are not sufficient to explain the adoption of CC in the context of ECs (Gupta *et al.*, 2013; Lian *et al.*, 2014; Morgan and Conboy, 2013; Li *et al.*, 2012; Low *et al.*, 2011; Lumsden and Gutierrez, 2013, Oliviera *et al.*, 2014). This work shows that the perceived disadvantages can limit the adoption and use of this disruptive technology.

Several perceived disadvantages are shown to limit the adoption of CC such as fear of losing control, security, privacy, data protection, performance and uptime, lack of cloud business brokers, and lack of awareness. In ECs the adoption of CC may be perceived as risky in relation to security and interfacing with internal and external systems (interoperability), ownership of content, and other legal requirements (Raval, 2010). Numerous international studies suggest that security is a major concern for organizations and entrepreneurs deciding whether to adopt CC (Phaphoom *et al.*, 2015, Martson *et al.*, 2011). "Outsourcing" the storage of all the firm's data potentially exposes the firm to several security problems. Concern over interoperability can also deter the move to CC. Firms need to keep open options related to the future of their IT systems, and might be wary of lock-in effects from adoption of CC. This does not apply to private CC which allows the firm to customize its services and uses to its existing technological options. Finally, there are legal issues associated with CC (Bradshaw *et al.*, 2011). These include limited liability of providers, conditions for ending an arrangement, and changes made by the provider. Many firms do not have the required skills and knowledge to evaluate these legal issues and prefer to continue with their existing information systems. Based on the above, we propose four hypotheses:

H2a: perception of cost reduction from CC affects CC adoption.

H2b: perception of time saving from CC affects CC adoption.

H2c: The greater firm's knowledge about CC, the greater the probability of its adoption

H2d: the more complex the technology is perceived to be the less likely it will be adopted.

2.3. Organization: absorptive capacity of the firm and CC adoption

Compared to DC firms, EC firms generally have a lower ability to innovate due to financial constraints and a less developed innovation system. EC firms might see disruptive technologies as an opportunity to catch up in innovation, and to increase their innovation performance. Firms' innovation capacity is measured by their technology ACAP.

Cohen and Levinthal (1989, 1990) proposed ACAP to describe the firm's capabilities to innovate, and thus, to be dynamic. ACAP includes the capabilities to recognize the value of new knowledge, to assimilate it and to apply it for commercial ends. Since Cohen and Levinthal's (1989) seminal work efforts have been made to refine this concept and their original model (see Zahra and George, 2002; Todorova and Durisin, 2007; Lane, and al., 2006; Lane and Lubatkin, 1998 among others).

In the present work we emphasize four important dimensions of firm ACAP firm which may differ between ECs and DCs namely: appropriability regime and its impact on the process of acquisition of new technologies; managers' skills and their role in recognizing the value of the technology; firm's ability to assimilate, transform and exploit the innovation; and coordination of tasks among employees. Our work relies strongly on the model proposed in Todorova and Durisin (2007) which reconciles and extends Cohen and Levinthal's (1989) and Zahra and George (2002) work.

The first dimension is the appropriability regime and was highlighted by Cohen and Levinthal (1989) and Zahra and Georges (2002) as important for ACAP. However, the authors are not in agreement about where to locate the effect of appropriability regime in their models. In the present work, we rely on the model proposed by Todorova and Durisin (2007) in which appropriability regimes both precede and follow ACAP. The adoption of a new technology or new knowledge is contingent on the approriability regime. At the same time, the ability to gain competitive advantage and produce innovation based on a new technology is contingent on the appropriability regime.

An important difference between ECs and DCs is the Intellectual Property Rights (IPRs) regime. EC markets are characterized by low efficacy of IPRs and easy replication. Firms fail to appropriate the returns from their innovations. Cohen and Levinthal (1990) show that the effect of appropriability regime on ACAP is negative. ACAP increases with a weak appropriability regime and competitive spillovers. We suggest that CC provides a solution to these problems related to innovation and its better protection. Most CC providers' hosting servers are located in countries where IPRs are respected. This could afford better protection of EC firms' data and innovation, suggesting that investing in CC and building ACAP are positively linked to IPRs.

The second dimension is related to recognition of the value of the new technology (knowledge). Firms often fail to identify new technological knowledge and to absorb new technologies because they are hampered by their embedded knowledge base, rigid capabilities, and path-dependent managerial cognition (Gavetti and Levinthal, 2000; Langlois and Steinmuller, 2000; Tripsas and Gavetti, 2000). Christensen and Bower (1996) show that the main problem is the inability of managers to properly assess the value of new knowledge that is not directly relevant to current demand from major customers. Aassessing the value of new technologies is very important. Managers often assess it based solely on the criterion of its implications for current customers and less on its potential future uses.

Managers play a prominent role in recognizing the value of a new technology. They are the principal actors in successful adoption of Information and Communication Technology (ICT) adoption and implementation in EC firms. The manager's profile (education level, age, style of command, ICT knowledge and skills, etc.) has a major impact on the adoption process (Amabile and Gadille, 2003; Low *et al.*, 2011). As the complexity of the technology increases, the support of senior management is essential to effect organizational change based on visible commitment. Top management support helps to overcome internal resistance to change (Lumsden and Gutierrez, 2013). The differences in managers' profiles, education, and ICT skills can play an important role in the process of adoption of new technologies especially CC.

The third dimension is the ability of the firm to assimilate and exploit the new technology. The implementation of new IT requires dedicated workers able to resolve problems and pass on their knowledge to other employees. This is particularly important in the context of EC firms. To some extent, technological ACAP is associated with the firm's technological readiness and can explain CC adoption. It reflects the firm's readiness for CC adoption (Lumsden and Gutierrez, 2013). CC adoption implies that the firm has accumulated skills and experience in previous generations of IT. Thus, intensity of use of IT can be a good proxy for the firm's ability to transform, assimilate and exploit CC. Although the firm may be convinced about the potential value of an innovation, lack of know-how related to implementation can be a barrier to its adoption. Knowledge that either facilitates implementation or highlights implementation problems potentially could affect the adoption decision (Greve, 2011).

The fourth dimension is the ability of the firm to transform its power relationships and internal organization. CC adoption can induce important organizational changes within the firm including changes to workers' roles, interaction patterns and power relations. These changes can disrupt routines and may require expert advice and support (Tiers *et al.*, 2013). The redesign of information systems can mean that several peripheral activities are outsourced or re-designated. At the same time, new applications may give access to new distribution channels (e.g. implementation of e-commerce). According to Raza *et al.* (2015), the main reason for the slow diffusion of CC is the lack of consensus among the IT workforce. Based on the result of a survey of IT workers at various organizational levels and in different countries, Raza *et al.* (2015) show that fear of losing one's job plays a huge role in the slow adoption of CC. This might also explain differences in the rates of adoption between Small and Medium-sized Enterprises (SMEs) and large corporations. It might also explain the difference in adoption of CC by DC and EC firms. Ben Youssef *et al.*, (2014) suggest that the complementarity between ICT and New Organizational Practices (NOP) adoption strengthens as the technology evolves. Adoption and use of the latest technologies are pushed by prior adoption of NOP. This implies that the adoption of CC requires adoption of NOP to support the organizational change. Based on the above, we formulate the following hypotheses:

H3a: The perception of IPRs linked to CC has a positive impact on CC adoption.

H3b: The intensity of use of IT has a positive impact on CC adoption.

H3c: The ICT manager's skills have a positive impact on CC adoption.

H3d: The proportion of IT workers in the firm's employment has a positive impact on CC adoption.

H3e: The ability of employees to change their patterns of coordination has a positive impact on CC adoption.

2.5. The Model

This section describes the econometric model and the empirical investigation strategy. Our conceptual model summarizes our general theoretical claims about CC adoption in the context of ECs. The theoretical model we have developed is contingent on several factors. We check the effects of three important variables which potentially could limit the generality of our claims.

The first control variable is firm size which is often considered a resource strength. Firm size is supposed to play an important role in the process of adoption of new technologies and has been demonstrated as a rank effect. The bigger the firm the better it is able to absorb and adopt new technologies. Firm size is linked to its financial and human resources, and the ability to solve problems and to take risks. Starting from these considerations, CC adoption is considered to be linked to firm size. However, we need to take account of the dual effects of firm size because while big firms have more resources to innovate and adopt new technologies, they are generally characterized by bureaucratic decision making processes and rigid rules and routines. The second variable is age. Age is considered a good indicator of firm resources. The longer established the firm the more experience and resources it will accumulate to cope with change, adopt new technologies and engage in innovation activities. For, age is supposed to have a positive impact on the adoption of new technologies. The third variable is sector of activity. Adoption of IT is contingent on the sector of activity. Many researchers have pointed to differences in the adoption and use of IT among sectors. Several industries are under continuous pressure to adopt new IT. For example, in Knowledge Intensive Sectors (KIS) keeping up to date is more important than in other sectors, since the

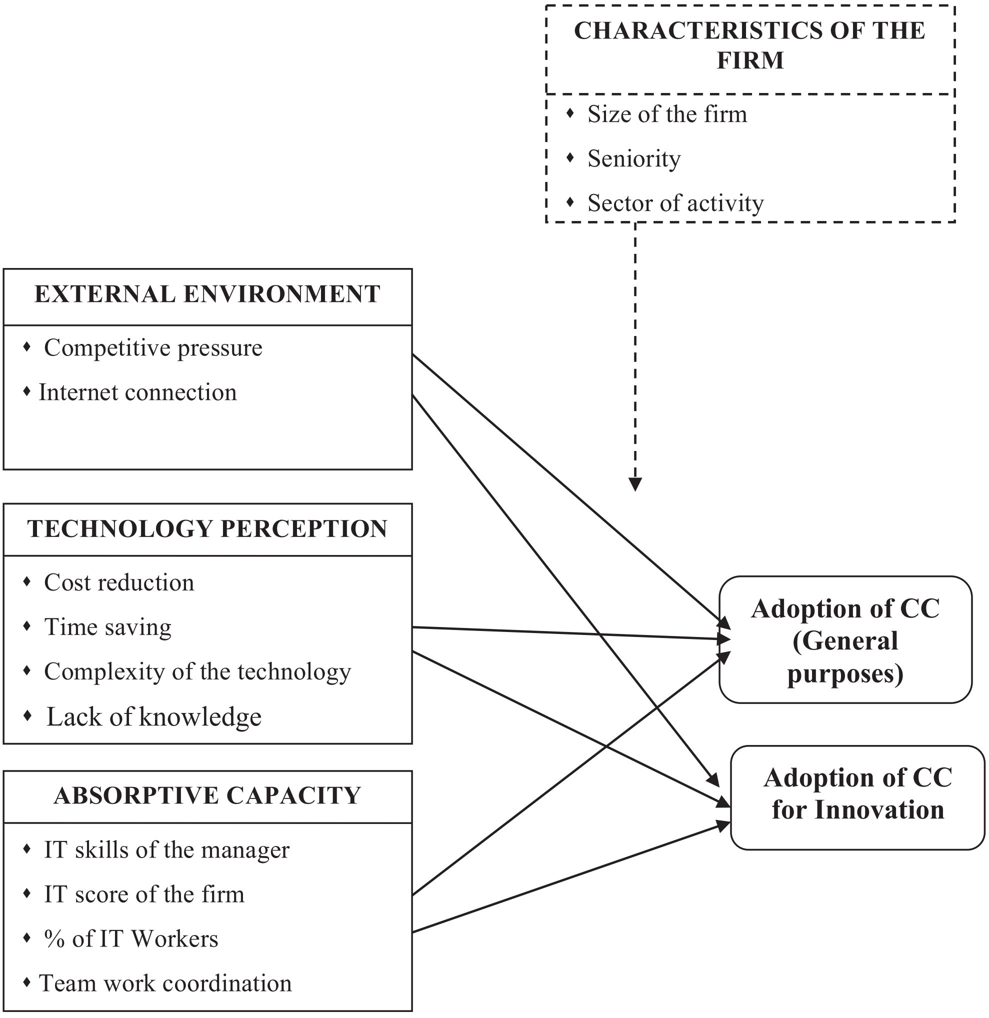

Figure 1. A model of the relation between adoption of CC by EC firms and their external environment, perception of technology and technological ACAP

core competencies or KIS firms are linked to innovation.

3. RESEARCH STUDY

3.1. The Context of Tunisia

Tunisia is a small, open country located in the North of Africa and close to Europe. It is considered an EC since its per capita Gross Domestic Product (GDP) around USD 11,380 (at 2014 purchasing power parity).[4] ICT penetration is important since most firms are well equipped with technology. In 2011, 74.7% of Tunisian firms had a broadband connection, 78.9% of firms used the Internet regularly, and 83.5% used computers in their daily jobs (INS, 2012). Several studies show that in the early stages, adoption of ICT relied mainly on social considerations and mimetic behavior (Bellon *et al.*, 2006; Ben Youssef *et al.*, 2012). While the adoption by firms of first and second generations of ICT was rapid, previous experience of technology and perceived advantages can slow adoption of later generations of ICT. Tunisia is an excellent object of study for the adoption of a new disruptive ICT such as CC, and allows investigation of the link between the adoption of the technology and the firm's ACAP.

3.2. Sample and data description

The survey was aimed at obtaining data on the level of CC adoption by Tunisian firms. Under our guidance, a private firm in Tunisia conducted the survey. Before its implementation, we checked the questionnaire for consistency. Each questionnaire was accompanied by a covering letter explaining the purposes of the study. Firm respondents who were all top managers were assured confidentiality.

The data were gathered via a face-to-face questionnaire administered in 2014 to a representative random sample of 350 Tunisian firms. The sample was representative of the Tunisian Economy. Survey respondents included firms active in Construction, Manufacturing, KIS and Less Knowledge Intensive Services (Less KIS). The firms were dispersed across all Tunisian regions and were selected randomly.

We obtained 311 usable surveys for data analysis, a response rate of nearly 90%. The high response rate is related to Tunisian legislation which obliges firms to respond to such surveys, our face-to-face approach, and the inclusion of a statement about the purposes of the research and guarantee of confidentiality of interviewees' responses. We think that these characteristics make our study particularly interesting in the context of investigating CC adoption and usage in Tunisia.

The survey was based on a set of questions related to the five core variables identified from the literature survey. It asked about CC adoption and usage. In this paper, we focus on the adoption decision; due to lack of data, we do not consider use and intensity of use.

Tables 1 and 2 present some details related to the sample.

[4] International Monetary Fund World Economic Outlook database, October 2014.

	CC Adoption	Mean(Age)	Mean(Size)
Yes	26.05 %	19.86	972.70
No	73.95 %	21.30	116.61

Table 1. Characteristics of adopters and non-adopters of CC in Tunisia

	Construction	Manufacturing	Less Knowledge Intensive Services (Less KIS)	Knowledge Intensive Services (KIS)
Adoption(%)	6.17	8.63	39.52	45.68

Table 2. Sample decomposition by economic sector

3.3. Two stages estimation method

In our sample, the data by definition are truncated. The aim is to find out for firms that have adopted CC, to what degree it promotes innovation. The question about the degree to which CC promotes innovation was posed only to firms that had adopted CC. The estimation method takes account of potential selection bias. We estimate a first stage probit model and a second stage ordered probit model using Heckman's (1979)[5] selection method. The model can be formalized as follows.

Let denote a dummy variable which indicates if the firm i adopted CC (d_i = 1) or not (d_i = 0). The Innovation CC variable *InnovCC* is observed only if d_i = 1 which in turn takes the value 1 (and 0 otherwise) if the latent variable d_i^* associated with d_i exceeds 0:

$$d_i = \begin{cases} 1 & if\ d_i^* = Z_i\alpha + u_i \\ 0 & otherwise \end{cases}$$

where u_i denotes an iid normal distributed error term; Z_i is a vector representing the variables that summarize the characteristics of the firm i; and α is a vector of unknown parameters associated with the vectors Z_i. These coefficients are obtained by running a simple probit model. The variable InnovCC follows the usual ordered probit specification and is observed if d_i = 1 :

$$InnovCC_i = \begin{cases} 1 \quad if \quad InnovCC_i^* = X_i\beta + \varepsilon_i \leq s_1 \ and\ if\ d_i = 1 \\ 2 \quad if\ s_1 < InnovCC_i^* = X_i\beta + \varepsilon_i \leq s_2 \ and\ if\ d_i = 1 \\ 3 \quad if\ s_2 < InnovCC_i^* = X_i\beta + \varepsilon_i \leq s_3 \ and\ if\ d_i = 1 \\ 4 \quad if\ s_3 < InnovCC_i^* = X_i\beta + \varepsilon_i \leq s_4 \ and\ if\ d_i = 1 \\ 5 \quad if\ s_4 < InnovCC_i^* \qquad and\ if\ d_i = 1 \end{cases}$$

[5] For more details, see Heckman (1976).

where $InnovCC_i^*$ denotes the latent variable corresponding to $InnovCC_i$, ss denotes the usual threshold parameters and X_i is a vector of the observable variables. The error terms u_i and are ε_i assumed to be bivariate normally distributed with correlation coefficient ρ and mean zero and variance 1: $(u_i, \varepsilon_i) \sim N_2(0, 0, 1, 1, \rho)$. The log-likelihood function corresponding to the ordered probit model with sample selection is:

$$\ln(L) = \sum_{d_i=0} \ln\big(1 - \Phi(Z_i\alpha)\big)$$

$$+ \sum_{d_i=1} \sum_{InnovCC_i=k} \ln\big(\Phi_2(s_k - X_i\beta, \alpha Z_i, \rho)\big) - \ln\big(\Phi_2(s_{k-1} - X_i\beta, \alpha Z_i, \rho)\big)$$

where α, β and ρ are obtained by estimating a probit model for d_i and transferring the estimates of α to the standard ordered probit model. The terms Φ and Φ_2 represent respectively, the univariate and the bivariate standard normal distributions.

3.4. The Variables

Dependent variables: We estimate two models in two steps: first a simple probit model and second an ordered probit. We construct two dependent variables:

1. *Adoption of CC*: a dichotomous variable that takes the value1 if the firm adopts CC and 0 otherwise;
2. *InnovationCC*: an ordinary variable from 1 to 5.

Explanatory variables: In this paper we consider three types of explanatory variable: (i) firm's external environment, (ii) firm's perception of the technology, and (iii) firm's technological ACAP.

(i) Environmental context: Most of the literature finds a positive relationship between the adoption of a given technology and its context (external environment). We consider two main variables related to firm context: competition intensity measured by adoption of CC by industry competitors, and Internet connection problems leading to non-adoption of more radical IT related innovations. This variable is binary and is based on self-reported answers. It takes the value 1 if the firm has Internet connection problems and 0 otherwise.

(ii) Firm's perception of the technology: Here, we consider four variables. The first two are related to perceived advantages: cost reductions and perceived time savings. They are binary variables based on self-reported responses. They take the value 1 if the firm perceives cost reduction and time saving as important and 0 otherwise. We second two variables are related to perceived disadvantages of the technology. The first refers to lack of knowledge in the firm about the technology. This is a binary variable based on responses to the question about the firm's knowledge of the technology. It takes the value 1 if the firm has no knowledge of CC and 0 otherwise. The second variable is perceived complexity which is also a binary variable based on the firm's self-reported answers. It takes the value 1 if the firm

perceives the technology to be complex and 0 otherwise.

(iii) Firm's ACAP: From our literature review we identified four variables related to firm ACAP. Manager's skills measured as ICT knowledge (the variable is measured as the score for the manager's use of IT based on the survey). The score varies between 0 and 5. The second variable is proportion of IT staff. It refers to the number of employees using IT in the firm. This is a continuous variable. Firms were asked whether CC facilitates employee coordination in the firm. This binary variable takes the value 1 if the firm experiences improved coordination from CC adoption and 0 otherwise. The fourth variable concerns IPRs. Firms were asked whether CC could secure IPRs or not. This binary variable takes the value 1 if the firm answered yes and 0 otherwise.

(iv) Control variables: We consider three control variables. Firm age measured as the number of years since establishment, firm size measured as the number of its employees, and firm's sector of activity which includes variables for KIS, Less KIS, Manufacturing and Other sectors. We control also for the squared age of the firm in order to check for the existence or not of nonlinear relationships. The variables are presented in table 3.

	Codes	Variables	Measures	Codifications
Dependent Variable	**Bivariate Probit** CC adoption	CC adoption	Binary =1 if firm adopts CC =0 if firm does not adopted CC	Dichotomy
	Ordered probit with sample selection Innovation CC	CC promotes innovation	Ordinary From 1 to 5	Ordinary
	Control variables			
	Age of the firm	Number of years since its birth	Number of years since its birth	Continuous
	Size	Number of employees	Logarithm of number of employees	Continue variable
	Size (squared)	The square number of employees	Logarithm of number of employees (squared)	Continue variable
	Sector	Economic activity of the firm	Others =0 Manufacturing =1 Knowledge Intensive Services (KIS) =2 Less KIS =3	Multivariate

	Codes	Variables	Measures	Codifications
	I. External Environment and Competition Pressure			
	Competition Pressure	Firms' competitors adopt CC	Binary =1 if Yes =0 if Not	Dichotomy
	Internet Connection Problems	Problems with Internet connection	Binary =1 if Yes =0 if No	Dichotomy
	II. Perceptions of the Technology			
	Cost Reduction	CC reduces cost	Binary =1 if Yes =0 if No	Dichotomy
	Time Saving	CC saves time	Binary =1 if Yes =0 if No	Dichotomy
	Complexity	Complexity of implementation of the CC	Binary =1 if Yes =0 if No	Dichotomy
	Knowledge	Problems related no knowledge of CC	Binary =1 if Yes =0 if No	Dichotomy
	III. Absorptive Capacity of the Firm			
	Intellectual Property Rights	CC promotes IPRs	Binary =1 if Yes =0 if No	Dichotomy
	ICT use	Score of ICT use by firm	Continuous	Continuous
	ICT Manager Skills	Score of 5 ICT use by the manager	Binary =1 if Score=5 =0 if Not	Continuous
	Employees using IT	% of employees using ICT	Between 0% and 100%	Continuous
	Employees' Coordination	CC facilitates employees' coordination	Binary =1 if Yes =0 if Not	Dichotomy

Table 3. Variables

4. RESULTS AND DISCUSSION

Table 2 summarized the main findings from our estimates. Two models were tested: a bivariate probit model for adoption of CC by the whole sample, and an ordered probit model focusing on the subset of firms that had adopted CC to foster innovation. We discuss the results of each model in turn.

	Bivariate probit CC		**Ordered probit with sample selection**	
	Coef.	*z-stat*	Coef.	*z-stat*
Control variables				
Age	-0.0164	*-1.46*	0.0154*	*1.73*
Age^2	0.0001	*1.14*	-0.0003	*-1.12*
Size	0.0003**	*2.04*	-0.0036	*-0.14*
Sector: *Other sectors*	Ref.		Ref.	
Manufacturing	-0.0470	*-0.13*	0.2408	*0.34*
Less KIS	0.6031**	*2.03*	-0.1698	*-0.27*
Knowledge Intensive Services	1.1769***	*3.77*	-0.0522	*-0.14*
External environment and competition pressure				
Competition Pressure	0.5120**	*2.29*	0.5755*	*1.68*
Connection	0.2517	*1.29*	-0.5199	*-1.33*
Perception of the Technology				
Cost Reduction	0.4147**	*2.17*	-0.2102	*-0.64*
Saves Time	0.2650	*1.24*	0.4884	*1.35*
Complexity	-1.0425*	*-1.76*	2.1165**	*1.97*
No Knowledge	-0.4465*	*-1.89*	0.0891	*0.85*
Absorptive Capacity of the Firm				
ICT Manager Skills	-0.1743	*-0.77*	-0.0243	*-0.56*
Employee Coordination	1.0317	*0.08*	0.7100**	*2.23*
% of employees using IT	0.3586**	*2.04*	1.0425**	*2. 81*
ICT use of the firm			0.1046*	*1.67*
IPR			0.86170**	*2.01*
# obs	311		81	
Prob > chi2	0.0000			

Table 4. Bivariate Probit Models Results

4.1. Adoption of CC: analysis of the entire sample

The bivariate probit model for the entire sample provides several important results with the respect to our hypotheses. We discuss the main ones below.

4.1.1. Environment: adoption of CC by competitors leads to imitative behavior

Our results show that there is a competition effect and confirms H1a. The more that competitors adopt CC, the more other firms adopt it. CC is considered to be a technology that can provide competitors with radical advantages, and reduce the focal firm's existing competitive advantage. There is also pressure from customers (Tiers *et al.*, 2013). Adoption of technological innovation may depend on a mimetic mechanism. However, this dynamic adoption is not found in all sectors. In KIS, CC may be considered a vital "input" but this is not the case for other industries and other sectors.

4.1.2. Technology: perceived advantages of CC lead to its adoption

Our results show also that adoption of CC is pushed by the perceived cost reducing potential of this technology. Adoption of CC is associated with the ability of this technology to reduce costs and to adjust to the real needs of the firm. It confirms hypothesis H2a. Our results confirm previous findings that the main driver of adoption of CC is financial (cost savings) (Reese, 2009; Marston *et al.*, 2011). Reese (2009) suggests that cost savings can reach extraordinary levels since the pay-per-use model is significantly cheaper than the prepaid model. At the same time, CC is supposed to result in reduced maintenance and implementation costs (Ransome and Rittinghouse, 2010). Our findings confirm that Tunisian firms are adapting their ICT usage to their needs, and cutting unnecessary costs. At the same time, adoption of CC has been stimulated by CC providers offering CC services at reduced cost or even for free. These promotions have increased deployment of this technology.

Our results show also that the perceived disadvantages of CC (perceived complexity, and lack of knowledge about its purpose) are the main forces behind its non-adoption. It confirms our hypothesis H2d. Both perceived complexity and lack of knowledge about CC purpose are significant. The more the technology is perceived as complex and the greater the firm's lack of knowledge about its purposes, the lower the probability of CC adoption. This confirms hypothesis H2c. CC is a new technology and there is available information on its purposes; most Tunisian firms perceive it to be a complex technology which perception may be linked to the skills of the firm's managers and/or owners. The quality of the firm's management is considered a key determinant of technology perception. Most models of technology adoption show that the complexity of a given technology depends on the perceptions of managers.

4.1.3. Organization: weak confirmation of the absorptive capacity effect

Our findings are contrasting. On the one hand, we found that the probability of adoption increases as the proportion of IT related work in the firm increases. The higher the proportion of the firm's employees that use IT the higher is the probability of CC adoption. This confirms hypothesis H3e. The proportion of employees using IT can proxy for accumulated tacit knowledge and the skills required for successful implementation of new generation IT. Adoption of CC depends on previous technology experience. On the other hand, we find that managers' IT skills have no effect.

Generally, the adoption of technological innovation induces organizational change. In the case of CC in Tunisian firms we can expect deep organizational change. Previous studies show that ICT use is reshaping Tunisian firms' internal organization. Most firms adopt new organizational practices after the adoption of ICT innovations (Ben Khalifa, 2014; Ben Youssef *et al.,* 2014). CC can accelerate this process and enhance organizational efficiency. However, our findings show that there is no link between the decision to adopt CC and the coordination of work among employees. This is an unexpected finding and may reflect problems linked to the attitudes and skills of entrepreneurs. Most are unable to perceive all the advantages of CC, and lack information on its potential especially related to the re-organization of tasks among employees.

4.1.4. Control variables: confirmation of the rank effect

Our study confirms the expected rank effect (i.e. firm size matters) found in the literature on the diffusion of IT innovations in the Tunisian context (Mouelhi Ben Ayed, 2009; Ben Youssef *et al.,* 2012). Firm size is indicative of the firm's financial resources, human capital stock and capabilities. The rank effect is not linked to the country's level of development. CC is expected to allow small businesses to access resources, and to benefit from technologies previously available only to large corporations (Marston *et al.*, 2011). However, our results show that in the early stages of adoption this does not hold. Big firms in ECs still benefit more from the potential of CC and their competitive advantage increases compared to small firms.

Our general model shows that in the Tunisian context the adoption of CC is linked more to the environment and technology perception than to the firm's ACAP. While we need to be cautious in relation to what are preliminary results, it could be argued that given the availability and novelty of the technology in the context of ECs, firms seem to be more interested in its general implications than its impacts on internal organization. As the knowledge about the purpose of the technologies and its applications improves, firms will be better able to evaluate its benefits for the firm's internal organization and its links to previous knowledge. Also, in the context of ECs such as Tunisia, most firms are small sized. This reduces the importance of the internal organization and internal knowledge but highlights the importance of managers for the process of adoption. Thus, the perceptions of the technology and competitors' behaviors are key drivers.

4.2. A focus on firms that have adopted CC for innovation reasons

The second ordered probit model was run for the subset of firms that had adopted CC to increase innovation, using the Heckman procedure, in order to better understand the determinants of adoption among innovative firms. We focused mainly on firms'

ACAP through the inclusion of more variables. We found several interesting and original results and important differences from the first model.

4.2.1. Environment: competitive pressure is still a key determinant of adoption of CC for innovative aims

The second model shows that the probability of adoption increases as the adoption of CC by competitors increases. Competition pressure is a key driver of CC adoption for both the subset and the entire sample. This confirms work on the firm's environment and its role in the process of innovation adoption (Tiers *et al.,* 2013). ECs generally experience less competition than DCs. As competition increases in ECs, more widespread adoption of technological innovation (especially CC) can be expected.

In relation to physical infrastructure, our findings are surprising. The model shows that the probability of CC adoption for innovation does not increase with better Internet connection. This perhaps can be explained by the existing Internet connection in Tunisia being considered satisfactory. This contrasts with the findings in the literature which find a particular effect of Internet connection (especially bandwidth) on the adoption process.

4.2.2. Technology: perception of the technology is less important if the objective is innovation

Our results show that the perception of the technology is not linked to the decision to adopt CC for innovative aims. Three out of four variables are not significant in our estimation - namely cost reduction, time saving and knowledge of the technology. This contrasts with previous results on the adoption of CC for general purposes. One explanation for this result might be that firms seeking innovation are aware of the potential benefits and costs of CC and have the necessary information on its aims. However, our results show that perceived complexity is still significant and plays a role. The more the technology is seen as complex the less likely firms will adopt it to increase innovation. Perceived complexity is an important dimension for innovation (Meeus *et al.,* 2001). In addition, technology complexity can induce fear related to the articulation with previous knowledge and the firm's routines after the adoption of the new technology.

4.2.3. Organization: strong confirmation of the absorptive capacity argument

Our model confirms that adoption of CC depends strongly on the firm's ACAP. Most of the variables considered related to the ACAP are significant. The percentage of IT staff is key to the adoption of CC for innovation reasons. The higher the percentage of IT staff the more likely the firm will adopt CC for innovative aims. At the same time, our model shows that the firm's intensity of ICT use is important for CC adoption for innovation, and confirms that CC adoption depends on previous knowledge about ICT, which reflects the ACAP argument.

Another interesting finding is that firms seeking to increase innovation through CC adoption are also keen to secure IPRs. Firms seem convinced that CC adoption will secure IPRs for their innovation and their intangible capital. Given the lack of legislation regarding IPRs in ECs, and especially in Tunisia, CC is seen as a way of improving the situation for these firms. The appropriability regime, a key element of ACAP is found to be linked to the adoption of CC.

The most important finding from our study is that CC adoption is based on two reasons: innovation and better coordination among employees. This implies that one objective of CC adoption is organizational change. Our findings confirm the complementarity between adoption of NOP and ICT proposed in Milgrom and Roberts (1990), and the finding in Ben Khalifa (2014) of the important impact of IT on the performance of Tunisian firms. In Ben Khalifa's sample Tunisian companies invest simultaneously in IT, organizational innovation and human capital. Ben Khalifa (2014) points to the special role of international contractors.

However, our model confirms that managers' IT skills have no effect on the adoption of CC. This contrasts with the findings in the literature that managers' IT skills are important for the adoption of IT in Tunisia (Bellon e*t al.*, 2006). In the case of CC, the picture seems different perhaps because CC is seen as a complex technology. Raza *et al.* (2015) suggest that managers make their decisions based on the skills of the IT staff. In our context CC adoption depends strongly on IT workers' beliefs and skills.

Overall, our model confirms the major role of firms' ACAP in the innovation process in the context of ECs.

4.2.4. Control variables: adoption of CC for innovative aims depends on the firm's seniority

While the rank effect applies to the entire sample it does not hold for adoption of CC to increase innovation. We found opposite dynamics for firm age. We found that the adoption of CC is not linked to firm age when we consider the whole sample but that the effect of firm age holds for firms that adopt CC to increase innovation. The experience and maturity of the firm is important for innovation in the context of ECs.

4.3. Limitations of our study

Our model should be considered preliminary. Although it provides several original results it has three main limitations. Firstly, most of the variables in our survey are binary and dichotomous. They do not allow us to examine the depth of adoption. Future work to include different and more quantitative variables. Secondly, adoption of CC has an important effect on the firm's internal organization. Unfortunately, our data allowed us to exploit only one dimension of organizational change and do allow us to observe other NOP. Beyond adoption of CC, effective economic gains depend on the ability of ECs to challenge organizational change and to adopt NOP. Without changes to internal organization the adoption of new IT can produce disorganization. Thirdly, to understand the pattern of adoption requires taking account of the dynamics of the process of adoption and use of CC and examining firms' decisions over several years. This was not possible with the data collected by the questionnaire. Finally, an alternative research strategy could consider a structural model of the decision to adopt CC with mediating variables and constructs. This could be an extension to our current work.

CONCLUDING REMARKS

This study set out to identify the determinants of CC adoption in ECs. It developed a theoretical framework to explain the decision to adopt CC adoption in an EC. It emphasizes the specific role of technological ACAP especially when the firm is seeking to innovate based on adoption of CC. It is a first exploratory investigation based on a sample of 350 Tunisian firms, and provides several important results. The adoption of CC depends on various external characteristics such as competitive pressure, perception of the technology as complex and perceived cost savings. Our results show that the adoption mechanism depends also on the firm's technological ACAP.

Our analysis goes beyond simple identification of the determinants of CC adoption by focusing on a subset of firms that have adopted CC for innovation reasons. We found contrasting results especially in relation to firms' perceptions of the technology and their ACAP. However, both models confirm the specific role of competition, and that managers IT skills have no effect. While perception of the technology is key to the adoption process (for general purposes), technological ACAP is the main determinant of adoption for innovation.

Our results have several policy and managerial implications. They show that in the Tunisian case, the main forces driving CC non-adoption are lack of adequate skills and perceived complexity of the technology. Policy makers could address both issues through appropriate information campaigns aimed at firm managers, to explain how the CC model works and what are its main benefits. At the same time, CC providers should advertise the advantages of the technology for firms. Adoption patterns are linked to the information provided, and the perceptions of managers. One of the main arguments for the adoption of this technology is its ability to cut unnecessary expenditure on ICT. Policy makers should emphasize this dimension.

Building skills in CC is difficult but is important to increase the competitiveness of Tunisia's economy. Several countries have implemented national strategies such as e-skills South Africa. These strategies are aimed at sensitizing firms to the application and value of these technologies and how firms can exploit them. South Africa provided training sessions and seminars over several years aimed at populating the national (South African) cloud. Tunisia should target firm managers and adopt a national CC strategy more generally.

ECs have the opportunity to leapfrog technology generations and adopt the latest technology at a faster pace (e.g. the case of mobile phone penetration).

In order to benefit from such opportunities governments need to promote a conducive environment and establish the institutional factors needed for SMEs to adopt CC. Many ECs such as India, Brazil, and South Africa, have invested hugely these activities. Tunisia should follow their example.

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