

META-LEVEL INSTITUTIONS IMPACTING ICT INNOVATION IN

DEVELOPING ECONOMIES:

Intellectual Property, the Digital Commons and

the Simputer's Process of Innovation

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ABSTRACT

Meta (global)-level institutions are increasing in significance with the inter-linking of national economies through processes of globalisation. This paper explores how two meta-level institutions, intellectual property (IP), especially copyright, and the digital commons (DC), contribute to or restrict Information and Communication Technology (ICT) innovation, as a process contributing to economic development, through an examination of innovation process transformation costs.

Seen through a case study examination of the Simputer's innovation, IP motivates ICT innovation, by both acting as a normative institution and by offering economic rewards, decreasing transformation costs through increasing access to innovation inputs. IP, providing the copyright, and the DC, opening the rights granted by copyright, together achieve open licensing, decreasing transformation costs through increasing access to innovation inputs. However, IP is seen to increase transformation costs while the DC decreases them. Lastly, the DC is shown to not provide support for a restricted access competitive strategy, increasing transformation costs through decreasing access to innovation inputs.

Given the role of innovation in the current informational economy, an understanding of the impact of these institutions on ICT innovation is opportune and contributes to exploring the connections between openness, innovation and development. Implications for ICT policy and research are provided, with suggestions for future research directions.

1.0 INTRODUCTION

The present economy is informational, based on Information and Communication Technologies (ICTs) (Castells, 2004; Dicken, 2007). It emerged in the U.S., and while developed economies are its lead participants, developing economies are gradually increasing their participation (Freeman & Perez, 1988; Dicken, 2007; UNCTAD, 2007). Participation in the informational economy is through innovation, a “driving force behind regional economic growth, standards of living, and international competitiveness” (Acs, 2002, cited in Acs, de Groot, & Nijkamp, 2002, p. 1; UNCTAD, 2007). Yet, innovation is impacted by institutions, which can both increase and decrease innovation productivity (North, 1990; Edquist, 1997; Lundvall, 1992a, Nelson, 1993 cited in Mytelka, 2000).

Institutions which impact ICT innovation exist at a number of levels, from the micro (organisational) to the meta (global). With the inter-linking of national economies through processes of globalisation, meta-level institutions emerge as increasing in significance (Dicken, 2007). In the globalised informational economy, a notable institution influencing ICT innovation is that which governs ICT ownership, use and control as it flows across borders: intellectual property (IP). However, there has been an increasing awareness of a potential disconnect between the efforts of donor country aid agencies to support socio-economic development goals through ICTs, and potentially opposing efforts by their respective governments to push developing economies to conform to international IP regimes (Kenny, 2006). IP, which encompasses copyrights and patents among other forms, is depicted as potentially restricting access to ICTs. In contrast, ICTs in the 'commons' are depicted as more accessible. The 'commons', or the digital commons (DC), works with IP to release rights granted to ICT innovators, thereby governing increasingly accessible ICTs. This demonstrates the DC as a potentially counterbalancing meta-level institution to IP.

This paper seeks to understand how an institutional perspective of globalisation impacts ICT

innovation, as a process contributing to economic development, in developing economies, with both IP and the DC as two significant meta (global)-level institutions. Montresor (2001) admits that there is agreement that globalisation has affected innovation, yet the research to date has failed to demonstrate definitive results. Additionally, conceptualisations of innovation have focussed significantly on the micro (organisational)- and macro (national)-level influencing factors (e.g. Freeman, 1987, Aydalot & Keeble, 1988, Lundvall, 1992a, Nelson, 1993, Camagni & Capello, 2002), which are more recently accounting for meta (global)-level factors (e.g. Stevens, 1990, Archibugi & Michie, 1997a, Mytelka, 2000, Montresor, 2001). This demonstrates the importance of additional contributions to understanding the meta-level impacts on ICT innovation in developing economies.

The study questions that:

How do the meta-level institutions of intellectual property and the digital commons impact – contribute to or restrict – ICT innovation in developing economies?

The impact of IP and the DC on ICT innovation will be specifically explored through an examination of how both enable (open) and constrain (close) access to ICT innovation inputs.

The research question is answered through the case study of an Indian ICT innovation, the Simputer (Simple Computer). The Simputer is a small, powerful, and low-cost handheld computer, originally designed by Indian innovators for use by the masses, in response to demand for affordable computing and Internet access points (Manohar, 1998; ST, 2001b; Fonseca & Pal, 2003). The paper is structured in seven sections including the introduction. The second section provides the economic context, conceptualises the process of innovation and institutions as those impacting innovation. The third section shows that IP and the DC are two meta-level institutions impacting ICT innovation, derives research propositions from literature for how they do this, and concludes with the framework for analysis. The fourth section presents the research methods for the study. The fifth section presents a

descriptive case study of the Simputer. The sixth section analyses the case of the Simputer through the framework for analysis. The seventh section concludes the research by outlining implications for policy and research, and offering suggestions for future research directions.

2.0 INNOVATION WITHIN THE INFORMATIONAL ECONOMY

The 1980s marked the beginnings of the current economic paradigm in the U.S., based on ICTs, notably computers, software, digital information technology, telecommunications, among others (Freeman & Perez, 1988; Dicken, 2007). Castells (2000, p. 77) describes the “new economy” as

“informational because the productivity and competitiveness of (...) agents in this economy (...) fundamentally depend upon their capacity to generate, process, and apply efficiently knowledge-based information”.

Evidence of the importance of the informational economy in the present day is demonstrated by the International Telecommunication Union's (ITU's) Digital Opportunity Index (DOI), showing a logarithmic relationship between national ICT infrastructure, opportunity and usage, and GDP per capita (ITU, 2007). It is reported that today's top 50 ICT firms are primarily in Europe and North America, with the U.S. in the lead. However, an increasing number of these firms are located in developing economies. Sixteen per cent of the top 50 ICT goods exporters and 24 per cent of the top 50 ICT services exporters are developing economies (UNCTAD, 2007, and see Appendix A).

Innovation is a “driving force behind regional economic growth, standards of living, and international competitiveness” (Acs, 2002, cited in Acs et al., 2002, p. 1; UNCTAD, 2007), and therefore a key process contributing to an agent's participation in the informational economy. Rogers' (2003, p. 138) Innovation-Development Process model details a general pattern of innovation stages: *need/problem recognition, research, development, commercialisation, and diffusion and adoption*. This process of innovation is not a direct and linear process (Edquist, 1997) and is indeed not complete at the *diffusion*

and adoption stage, but in fact continues:

“... [diffusion] also involves continuing, often incremental, technical change by which the original innovations are (i) moulded to fit particular conditions of use (...), and (ii) further improved to attain higher performance standards...” (Bell and Pavitt (1997, p. 86).

Given the incremental nature of the innovation process, access to existing innovations as inputs to future innovation processes is necessary. Benkler (2006, p. 37) specifies that “information is both an input and output of its own production process”, describing the “on the shoulders of giants” effect, the same can be said for innovations themselves. Mytelka (2006, p. 862) states that incremental innovations “were the hallmark of earlier catch-up strategies” by developing economies. The innovation process can therefore be conceptualised as continuous cycles of iterations, with incremental innovation being an important form of innovation in developing economies. This research will focus on the *development* stage of the Innovation-Development Process model, in which the innovation is put into a usable form (Rogers 2003). This may be something new, or more often, a new combination of existing innovations (Nelson & Rosenberg, 1993; Edquist, 1997; Rogers 2003). These innovation processes occur within an institutional context, impacting the continuous cycles of incremental iterations. Hence, understanding the impact of institutions on access to innovation inputs by developing economy innovators, specifically how institutions both enable (open) and constrain (close) access to inputs, can contribute to our knowledge of the relationship between institutions and ICT innovation, as a process contributing to economic development.

2.1 Institutions and ICT Innovations

The renewed interest in institutionalism, termed 'New Institutionalism' (NI), attempts to introduce a higher level of theoretical rigour to an older field which recognized the role of social, political and economic institutional arrangements, yet was highly descriptive only (Coase, 1983, cited in Scott, 1995; DiMaggio & Powell, 1991). NI is not a single body of theory, but a theoretical framework from

the social sciences, with a number of disciplinary interpretations, “that aims to explain (...) the interplay of agency and institutions in shaping processes of governance” (Goodin, 1996; Ciborra, 1983, Drobak & Nye, 1997, Goodin, 1996, Lane & Ersson, 2000, cited in Santos, 2005, p. 3). NI was developed from roots in technological innovation (DiMaggio & Powell, 1991; Lowndes, 1996; Santos, 2005), and according to King et al.'s (1994, p. 139) initial exploration on institutional factors in ICT innovation, NI “provides a stronger base for understanding the role of institutions in I[C]T innovation”, than previous attempts from neoclassical economics and organisational theory.

Institutions define, constrain and enable action and choice of individuals and organisations (North, 1990; Lowndes, 1996). Institutions themselves are the products of individuals and organisations, yet they constrain and enable these in different ways, imparting uneven power (North, 1990; Goodin, 1996; Lowndes, 1996). Institutions may not result in the most efficient actions, as they can both increase and decrease innovation productivity (North, 1990). Both North (1990) and Lowndes (1996) distinguish between informal and formal institutions. Informal and normative institutions are not consciously designed nor explicitly stated and enforced, such as customs, societal norms and traditions (Colson, 1974, cited in North, 1990; North, 1990, DiMaggio and Powell, 1991; Scott, 1995; Lowndes, 1996; see Appendix B). They are “socially transmitted and are a part of the heritage that we call culture” (North, 1990, p. 37), and are therefore shared by a community or society (Lowndes, 1996). Formal and regulative institutions are legally sanctioned, such as explicit laws, rules, and regimes (North, 1990; DiMaggio & Powell, 1991; Scott, 1995; Lowndes, 1996; see Appendix B). The increasing complexity of systems and societies creates the motivation for formalisation of constraints (North, 1990; Knight, 1992, cited in Lowndes, 1996). See Appendix B for additional definitions of institutions by institutionalists.

The disciplinary view from economics, termed the 'New Institutional Economics' (NIE) is of particular interest to this investigation given the examination of ICT innovation as a key process contributing to

an agent's participation in the informational economy. Early institutionalists challenged the neoclassical economic paradigm which assumed the existence of “idealized free agents interacting in an idealized free market” (Goodin, 1996, p. 7), thereby ignoring the economy's institutional reality (Veblen, 1898; Commons, 1924; DiMaggio & Powell, 1991; Lowndes, 1996; Coase, 1998; Williamson, 2000). However, both early and new institutional economists subscribe to many of the same ideas, principal among them is that the primary unit of analysis is the transaction, and more specifically, transaction costs (North, 1990; DiMaggio & Powell, 1991; Williamson, 1975; Williamson, 2000).

As earlier stated, innovation is a process which necessitates inputs of existing innovations. We can therefore consider more specifically, how do institutions impact access to innovation inputs?

Transaction costs from New Institutional Economics, defined broadly by Arrow (1969, p. 48, quoted in Williamson, 1991) as the “costs of running the economic system” offer an interesting starting point. In Williamson's (1981, cited in Orrù, Biggart, & Hamilton, 1991) view, a transaction cost approach reflects the variable and differential access to technologies, financial resources and markets, while Arrow (1969, p. 48, quoted in Williamson, 2003) states that transaction costs “impede and in particular cases completely block the formation of markets”. North (1990, p. 28) provides a needed level of specificity by emphasising that the costs of production, or innovation development, are the sum of those of transformation and those of transaction:

“The total costs of production consist of the resource inputs of land, labour, and capital involved in both transforming the physical attributes of a good (...) and in transacting ...”

North (1990) additionally states that transformation and transaction costs are both a function of the technology employed and institutions. The concept of transformation costs is therefore very relevant as we seek to understand how institutions impact access to innovation inputs: access to innovation inputs factor into transformation costs.

When considering the many forms of access to ICT inputs to the innovation process in developing economies, Wilson (2004) provides a good starting point with his model of ICT access, based on empirical data from Brazil, Ghana and China, which we term the ICT User Access model. Through such a model, he sought to conceptualise the many forms of barriers which users encounter in accessing ICTs, contributing to the digital divide, which he defines as “an inequality in access, distribution, and use of [ICTs] between two or more populations” (Wilson, 2004, p. 300). The eight dimensions of ICT User Access are: *physical, financial, design, cognitive, content, production, institutional, and political* (Wilson, 2004). Wilson (2004, p. 305) himself notes that the concept of access is associated with the passivity of the user, and is in fact insufficient – rather he admits that “the more active ICT innovators there are in a society, the more likely it will become a knowledge society”. Therefore, building on Wilson's ICT User Access model, we can consider the dimensions of access to ICTs as inputs to the innovation process, with this research consider the *physical* dimension of access as the most basic form to the innovation process. We propose to define *physical* access as that to tangible (hardware) and intangible (software) innovation inputs. A secondary applicable dimension, *knowledge* access, combining *design, cognitive* and *content* access, and defined as access to the learning process, knowledge and information required for innovation, won't be considered due to scope limitations.

3.0 META-LEVEL INSTITUTIONS IMPACTING ICT INNOVATION

Important starting points when considering meta (global)-level institutions impacting ICT innovation are the 'Systems of Innovation' conceptualisations. These have traditionally focused on the micro (organisational)- and macro (national)-level influencing factors (e.g. Freeman, 1987, Aydalot & Keeble, 1988, Lundvall, 1992a, Nelson, 1993, Camagni & Capello, 2002), yet are more recently accounting for meta (global)-level factors (e.g. Stevens, 1990, Archibugi & Michie, 1997b, Mytelka, 2000, Montresor,

2001). A review of this literature demonstrates that there are a number of meta-level institutions impacting ICT innovation. A meta-level institution of high relevance to the informational economy is intellectual property (IP), which provides the international legal framework governing ICT ownership, use and control as it flows across borders. A second institution, not commonly emerging in past innovation literature, but more recently, such as in the work of Benkler (2002, 2006), is the commons, or the digital commons (DC), which works with IP to release rights granted to ICT innovators, thereby governing increasingly accessible ICTs, emphasising the importance of its examination as a potentially counterbalancing institution to IP.

3.1 Intellectual Property

IP is a legal framework of time-delimited rights granted to the producers of innovations in order to control their use (Foray, 2004; WIPO, 2004b). IP includes a wide spectrum of forms, with copyrights and patents as the two forms predominantly applicable to ICTs (Foray, 2004; Bannerman, 2007), with this research focusing on the former. While a patent protects an idea, a copyright protects the expression of an idea (May, 2007). Copyright therefore applies to software source and object code, and grants the copyright holder the rights to reproduce the work, create derivative works from it, distribute it, among other rights (Story, Darch, & Halbert, 2006).

IP emerged as a mechanism to encourage innovation through providing innovators rights and protections allowing them to benefit economically from their innovations (Bannerman, 2007; May, 2007). According to the UN's World Intellectual Property Organisation (WIPO) (2004b, p. 3) one of the reasons for IP is to “encourage fair trading which would contribute to economic and social development”. As a legal framework encompassing laws governing the use of innovations, IP is a formal and regulative institution. It is institutionalised at the meta-level through coordinated efforts at UN agencies, namely the WIPO and the World Trade Organisation (WTO), and through multi- and bilateral agreements and treaties. A key multilateral agreement is the WTO's Agreement on Trade-

Related Aspects of Intellectual Property Rights (TRIPS), which establishes minimum standards of IP protection that all WTO members, which are the majority of the world's countries, must grant to each other (WTO, n.d., p. 1; Drahos & Braithwaite, 2002). TRIPS is therefore recognized as a significant mechanism which has globally institutionalised IP (Drahos & Braithwaite, 2002).

3.1.1 Intellectual Property as an Enabler of ICT Innovation

IP rewards innovators through the granting of property rights leading to economic benefits (May, 2007), thereby acting as an incentive to innovation. A World Bank report (WB, 2002, p. 130) states the following clear rationale for IP:

“It is often costly to develop new technologies and products, requiring considerable investment in research and development (R&D) with uncertain payoffs. (...) These costs must be recovered through a temporary ability to set prices above marginal costs of production.”

Society benefits indirectly through the continual development of socially valuable innovations, while society also benefits directly through the disclosure of innovations (Bannerman, 2007; May, 2007).

With economic rewards as an incentive to innovate, ICT innovation increases, therefore physical access to innovation inputs is increased, decreasing transformation costs. This leads to this research's first proposition:

Proposition 1: IP enables ICT innovation, as potential economic rewards act as an incentive to innovate, increasing physical access to innovation inputs.

While economic rewards is the focus in this proposition, and economic development the form of development of focus for this paper, we acknowledge that there are other very important 'rewards' and forms of development to which ICT innovation makes a contribution. These include human, ethical, social and environmental, which are not directly economic, but related via market demand and competition, and can act as strong incentives to innovate.

3.1.2 Intellectual Property as a Constraint to ICT Innovation

The strengthening of IP protection entailed by WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) through the extension of copyright scope and duration, as it applies specifically to software, has been shown to reduce the opportunity for incremental innovative strategies adopted by developing economies. With respect to copyright, software source and object code became copyrightable under TRIPS (WTO, 1994), with copyright's duration set at a minimum of 50 years when it is not based on the life of the author. This is in great contrast to ICT product life-cycles which are shortening to be on average two to three years (UNCTAD, 1997; Wade, 2003; Kim, 2004). With the expansion of scope and duration of copyright protection, physical access to innovation inputs is decreased, increasing transformation costs. This leads to the research's second proposition:

Proposition 2: The expansion of IP's scope and duration *constrains* ICT innovation as physical access to innovation inputs is decreased, through increasing restrictions on access and use of ICTs.

3.2 The Digital Commons

Benkler (2006, p. 60) provides an overarching definition of the commons: “ 'Commons' refers to a particular institutional form of structuring the rights to access, use, and control resources”. To the ICT innovator, these resources are digital and include principally software code (Lessig, 2001; Armstrong & Ford, 2005). Software source code in the digital commons is either considered 'open source' or 'free software', with free not meaning gratis but freedom, denoting it as free from copyright restrictions (GNU, 2008c). Software becomes open or free when there are copyright restrictions removed through the application of an open license, with the GNU is Not Unix (GNU) General Public License (GPL) as the central license (Benkler, 2006; GNU, 2008b). In addition to the GNU GPL, we acknowledge the numerous forms of Creative Commons open licenses, however, as these are primarily applied to content, and not software, they are outside of the scope of this paper (Cheliotis, Chik, Guglani, & Tayi, 2007; Cheliotis, 2009). The GNU GPL grants the rights to run, modify, with modified versions

required to keep the GNU GPL, and redistribute the software program, for commercial or non-commercial purposes (GNU, 2008b; GNU, 2008d). The digital commons encompasses not only works which are protected by IP yet under an open license, but also works in the public domain, which are free of IP protection (Stallman, 1999; Lessig, 2001; Armstrong & Ford, 2005; Story et al., 2006).

While IP is a legal framework, the digital commons is made possible by legal frameworks, specifically IP and contract law for open licenses (Lessig, 2001). Therefore, similar to IP, the DC is a formal and a regulative institution. At the meta-level, it is institutionalised by the organisations which produce the open licenses, principally the Free Software Foundation (FSF), responsible for the GNU GPL (FSF, 2008b). In the case of FLOSS development, Weber (2004, p. 179) views the legal frameworks as indeed institutionalising innovation, with the formal leading to an informal institutionalisation:

“the license becomes the core statement of the social structure that defines the community of [FLOSS] developers (...). One way to manage complexity is to state explicitly (in a license or constitution) the norms and standards of behaviour that hold the community together.”

The specific growing body of software code in the digital commons, which is built by both individual and collaborative efforts of innovators, has come to constitute an increasingly global movement of networks and communities, according to the FSF (2008c). Indeed, there is growing evidence that this is the case not only in developed regions, but in Latin America, Africa and Asia (Shimizu, Lio, & Hiyane, 2004; May, 2006; Zúñiga, 2006). Although it is a formal/regulative institution, it can be seen additionally as an informal/normative global institution.

3.2.1 The Digital Commons as an Enabler of ICT Innovation

The DC can be seen as a response to the strengthening of IP as an institution, by lessening restrictions on access and use of software source code, and a promising means by which knowledge can be transferred to developing economies (UNCTAD, 2007; Kerr, 2008). Lessig's (2001, p. 13) work examining the increasing enclosure of the DC demonstrates that “the availability of a resource that

remains outside the exclusive control of someone else (...) has been central to progress in science and the arts". By simply loosening the restrictions imposed by IP which are increasingly strengthened through TRIPS, the DC legally grants access where it wasn't previously granted. Therefore, the DC enables ICT innovation through an increase in physical access to innovation inputs, decreasing transformation costs. This leads to the third proposition:

Proposition 3: The DC *enables* ICT innovation by lessening restrictions on access and use of software, thereby increasing physical access to innovation inputs.

3.2.2 The Digital Commons as a Constraint to ICT Innovation

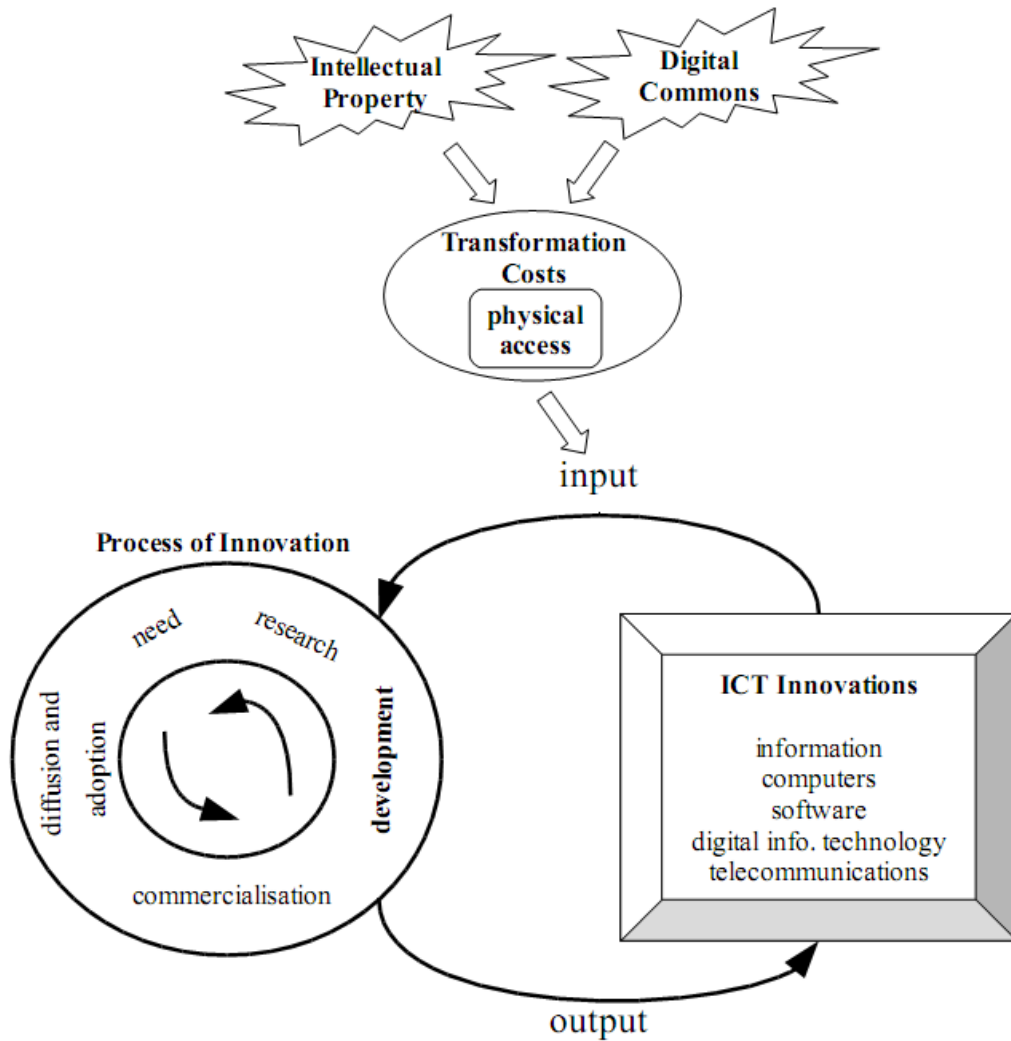
There are a number of constraining factors with varying levels of importance which have emerged in the literature contributing to a lowering of physical access to resources in the DC as inputs to the innovation process. In relation to software code, as FLOSS is accessible primarily over the Internet, technical infrastructure challenges found in developing economies are physical access barriers (Weerawarana & Weeratunga, 2004; Kenny, 2006; May, 2006). This points to a relevant factor to this research constraining physical access to innovation inputs, increasing transformation costs. This leads to the fourth proposition:

Proposition 4: The DC *constrains* ICT innovation through technical infrastructure challenges in developing economies, decreasing physical access to innovation inputs.

To summarise, the above discussions posits that both IP and the DC can enable and constrain physical access to innovation inputs in different ways, according to Propositions 1 through 4. The ICT innovation process is continuous, and has as inputs ICT innovations, which are transformed into outputs of the same, to be used as future innovation inputs. As transformation costs, IP and DC are meta-level institutions impacting physical access to ICT innovation development inputs. We can therefore see the emergence of our framework of meta-level institutions impacting ICT innovation,

conceptualised in Figure 1.

Figure 1: Meta-Level Institutions Impacting ICT Innovation - Conceptual Framework



Source: developed from Freeman & Perez (1988); North (1990); Lundvall (1992b); Nelson & Rosenberg (1993); Bell & Pavitt (1997); Edquist (1997); Rogers (2003); Wilson (2004); Benkler (2006); Dicken (2007).

From this conceptual framework, there are four questions to be used as guides in our analysis:

The Impact of Intellectual Property on ICT Innovation:

1. How does IP *enable* access to physical inputs to innovation development?
2. How does IP *constrain* access to physical inputs to innovation development?

The Impact of the Digital Commons on ICT Innovation:

3. How does the DC *enable* access to physical inputs to innovation development?

4. How does the DC *constrain* access to physical inputs to innovation development?

These four questions will be examined through one or both of: innovation inputs; and innovation outputs, which are themselves, future innovation inputs, recognizing the continuity of the innovation process.

4.0 RESEARCH METHODS

This research seeks to examine how the meta-level institutions of IP and the DC impact ICT innovation in developing economies. In order to get richness of experiences and conduct an in-depth investigation, a descriptive case study was undertaken. Case studies are particularly appropriate when “an empirical inquiry must examine a contemporary phenomenon in its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Yin, 2003, p. 13), emphasising its importance as a method given the context of study.

The case study was based on an Indian ICT innovation, the Simputer. India had been selected as the research site as it exhibits relative resource poverty with a medium human development classification (UNDP, 2007), yet with a visible track record in ICT innovation, ranking second after China among developing economy ICT goods and services exporters (UNCTAD 2007, Table 2.11, Table 2.14, and see Appendix A). The Simputer was chosen as it most importantly satisfied the criteria of exhibiting strong influences of both institutions under study, with an interesting dynamism between the two not previously seen by the researchers, who had been principally exposed to cases where IP constrained and DC enabled ICT innovation only. Secondly, both the maturity of the Simputer's innovation process and the extent of its historical account, provided a rich case for this investigation. In summary, the case study was strategically selected since it provided particular characteristics relevant for the examination of our research questions and propositions (De Vaus, 2001, p. 288), case study researchers have noted this as theoretical sampling (Glaser & Strauss, 1967) and focused sampling (Hakim, 1986).

The case study was based on both primary and secondary data sources, principally texts. The data was collected over a three month period, from June to August 2008. Primary text-based sources used include the Simputer project documents produced by the innovators, web-based technical documentation, media accounts and project community discussion group archives, and an email-based interview with a lead Simputer innovator was conducted in order to fill information gaps. Software source code linked to the Simputer project was examined to verify software licenses and from which previous software it was derived. The study of the project's documentation and literature was done following identified best practices, notably critically assessing the findings and conclusions in context and the politics of the data's source (Barrientos, 1998; O'Laughlin, 1998; Laws, 2003; Branley, 2004). The wide variety and amount of information available on the Simputer project facilitated the triangulation process.

The case study was analysed in consideration of theoretical propositions, an analytic strategy as outlined by Yin (2003). While propositions were derived throughout the literature review, the researchers remained open to alternative and new explanations for IP's and the DC's impact on ICT innovation. The mode of inference for analysis was retroduction, which is a “mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them” (Sayer, 1992, p. 107, cited in Downward & Mearman, 2007). Knowledge of the social phenomenon of study, in this case ICT innovation, was acquired by examining the broader mechanisms and conditions, IP and the DC as institutions, which shape the phenomenon's existence (Danermark, Ekstrom, Jakobson, & Karlson, 2002).

5.0 THE CASE OF THE SIMPUTER AS AN ICT INNOVATION

5.1 Background

The Simputer (Simple Computer) is a small, powerful, and low-cost handheld computer, originally designed by Indian innovators for use by the masses, in response to demand for affordable computing and Internet access points (Manohar, 1998; ST, 2001b; Fonseca & Pal, 2003). The ideas for the Simputer emerged at the end of 1998, which were described in a number of key documents, principal among these was the Bangalore Declaration, which states that:

“Information Technology presents developing countries with a historic window of opportunity that enables them to create national wealth and break the cycle of poverty and dependence...”
(Chandru & Manohar, 1998a, p. 1).

The Simputer was subsequently designed and developed, primarily by a core group of professors from the Indian Institute of Science (IISc), Bangalore (Fonseca & Pal, 2003), who formed the Simputer Trust, a non-profit entity innovating the Simputer, with the “broad goal of harnessing the potential of Information Technology for the benefit of the weaker sections of society” (ST 2001b, end). The Trust, as the innovating entity, licensed the Simputer hardware designs and provided FLOSS software applications to manufacturers (ST, 2001b). It was initially manufactured by Encore Software as of 2003, then in 2004 by PicoPeta Simputers, a firm formed by IISc Simputer innovators, which has since been acquired by Geodesic Information Systems (Fonseca & Pal, 2003; PicoPeta, 2005). In 2005, it was reported that Encore and PicoPeta had each sold approximately 2,000 units, which was well below predictions (LD, 2005). Although Simputers still appear available for sale by Encore and Geodesic on their respective websites, both websites appear stale, though interest in the project continues through the Simputer, Simputer Developer and Amida Simputer Enthusiast community mailing lists (Amida, n.d.d; Encore, n.d.; Yahoo, 2008a; Yahoo, 2008b; Yahoo, 2008c).

As the *development* stage is that in need of direct innovation inputs, the Simputer project will be

explored through this stage, in addition to the *need/problem recognition* and *research* stages in order to explore how IP and the DC emerged in the context and motivations for the Simputer's innovation.

5.2 Need / Problem Recognition and Research Innovation Stages

Drafted by Simputer innovators Chandru and Manohar (GV, 1998), the Simputer-visioning Bangalore Declaration provides a number of references to IP, with only a single reference to the DC, with select references outlined in Table 1 below.

Table 1: Intellectual Property and the Digital Commons in the Bangalore Declaration

<i>Recognitions</i>
“...that in the next millennium, intellectual property will be the yardstick for assessing the wealth of nations.”
<i>Proclamations</i>
7. “The latent intellectual talents in a developing country should be harnessed to create monetarised intellectual property in I.T., as this can lead to the rapid generation of national wealth.”
“We therefore call upon developing countries to (...) 12.3 Give priority to education, without which the human resources of the populace will not be developed. Governments should therefore (...) nurture advanced engineering and technology education geared to the creation of intellectual property in I.T. (...) 22. Utilise the many sophisticated packages and systems tools that are available today, as free and public domain [DC] software , to create unique solutions using such software and thus contribute to the global enterprise in free [DC] software .”

Source: developed from Chandru & Manohar (1998a)

The Bangalore Declaration notes that IP will be a wealth indicator, and therefore calls for the creation of IP in ICT for income-generation, while at the same time calling for the use of and contributions to FLOSS.

5.3 Development Innovation Stage

Although the development of the Simputer went through a number of phases, it can be seen through two distinct phases. The first phase is the innovation's development by IISc professors as evidenced

through innovation outputs of the Simputer Trust. This phase started from the *need/problem recognition* stage in 1998, through to the *research* stage, until the establishment of PicoPeta Simputers. The second phase is the increasing involvement in PicoPeta by IISc innovators, as a venture through which to commercialise the Simputer, known as the Amida Simputer by PicoPeta, until the present time.

While Encore is an innovating firm who manufactured the Simputer through licensing the Simputer Trust's hardware designs, insufficient data about their innovation process, and how IP and DC were factors, is known.

5.3.1 First Phase of the Development Innovation Stage: Simputer Trust

While the Simputer's development can be seen as being principally motivated by an interest to bridge the digital divide through 'universal access' to ICTs, a second development philosophy presents itself in one of its visioning documents. Chandru and Manohar (1998b) outline that developing economies are importers of hardware and software from developed economies, and adapt these to suit local needs, if possible. Instead of continuing the cycle of dependency, they advocate for governments to “encourage development of unique solutions for the unique needs of developing economies”, “through the development and deployment of indigenous hardware, software and systems products” (Chandru & Manohar, 1998b, sect.5).

The Simputer was initially developed by leveraging a significant amount of software from the DC. Table 2 outlines a non-exhaustive list of the main software applications and hardware device drivers used as innovation inputs to the Simputer, as developed by IISc innovators through the Simputer Trust.

Table 2: Simputer Main Software Components

Name and Description	License	Role of Simputer Trust
<i>GNU/Linux</i> : The operating system.	GNU GPL	Adaptors
<i>Information Markup Language Interface (IMLI)</i> : A browser for displaying information.	GNU GPL	Developers
<i>Dhvani</i> : Text-to-Speech software.	GNU GPL	Developers
<i>Smart Card driver</i>	GNU GPL	Developers
<i>Tapatap</i> : Generates keystrokes in the absence of a keyboard.	GNU GPL	Adaptors

Source: developed from ST (2000a); ST (2000b); ST (2000c); ST (2000d); ST (2000e); ST (2000f).

The version of *GNU/Linux* adopted was tailored for their chosen processor, allowing the Trust to leverage existing innovations, and to make changes as required (ST, 2000e; ST, 2001b). The Trust's FAQ opines, “[t]o write these from scratch would make it infeasible to even conceive of such a project” (ST, 2001b, no.32). There have been no updates on the Trust's website for these software applications since 2001 (ST, 2001a).

5.3.2 Second Phase of the Development Innovation Stage: PicoPeta's Amida Simputer

During the second phase, there is an apparent shift in focus from IISc innovator activity at the Simputer Trust to activity at PicoPeta. While innovation development had appeared to have been stopped by the Trust, activity appeared to have increased at PicoPeta. PicoPeta's Amida Simputer saw the introduction of a number of new software components, greatly increasing in number due to the product's advanced maturity in this stage. Table 3 details a sampling of the significant innovative components.

Table 3: Sampling of PicoPeta's Amida Simputer Main Software Components

Name and Description	License	Role of PicoPeta
<i>Doodle n' Mail</i> : Email handwritten notes.	?	Developers
<i>Web Browser</i>	?	Developers/Adaptors
<i>Flip Motion Sensor</i> : Turn pages by hand gesture response.	?	Developers
<i>Chikki</i> : To run an application from an external memory stick.	?	Developers

Source: developed from Amida (n.d.b); Amida (n.d.f); OA (n.d.c).

While GNU/Linux continued as the Amida Simputer's operating system, it is clear that PicoPeta adopted a more apparent strategy of closed-source development: the source code was not accessible for download, nor the software's object code, for the Amida's applications and device drivers. The web browser was noted as being derived from an existing FLOSS application, under the GNU GPL license (Karpov, n.d.), and no information is provided on the Chikki's development. However, the web browser, as well as other applications on the device, were built using the Alchemy window manager, which was PicoPeta's explicitly proprietary user interface framework for Amida applications (Amida, 2004; Amida, n.d.c), and considered a significant innovation. Manohar (2008, p. 1) explains that Alchemy was built from scratch and was made proprietary in order to differentiate PicoPeta's Amida Simputer from Encore's offering:

“there are many avenues for differentiation [from Encore]: cost, hardware functionality, application layer, etc. PicoPeta chose to bet on a powerful application layer [Alchemy window manager] to differentiate its Amida Simputer from the competition”.

Although PicoPeta had developed the Alchemy window manager as closed source, it had invested significant efforts into the development of the Amida Alchemy Software Development Kit (SDK) (Amida, 2004). The SDK included the Alchemy window manager's proprietary object code at its core,

in order to make it easy to develop new applications for the Amida Simputer (Amida, 2004; Manohar, 2008). While the SDK is offered for purchase, it is possible to download a version free of cost from the Amida Simputer's website (Amida, n.d.a; Amida, n.d.e). Therefore, while the Alchemy window manager was proprietary, it remained accessible and free of cost as object code.

In 2006, it was realised that Encore, their only Simputer competitor, was no longer a major one, and therefore Geodesic, the company which had acquired PicoPeta, made the decision to release Alchemy's source code under the GNU GPL license, calling it OpenAlchemy, with a commercial non-GPL license additionally available (OA, n.d.a; OA, n.d.b; Noronha, 2007; Manohar, 2008). This decision was also in response to demand to make the Alchemy window manager's source code available (Noronha, 2007).

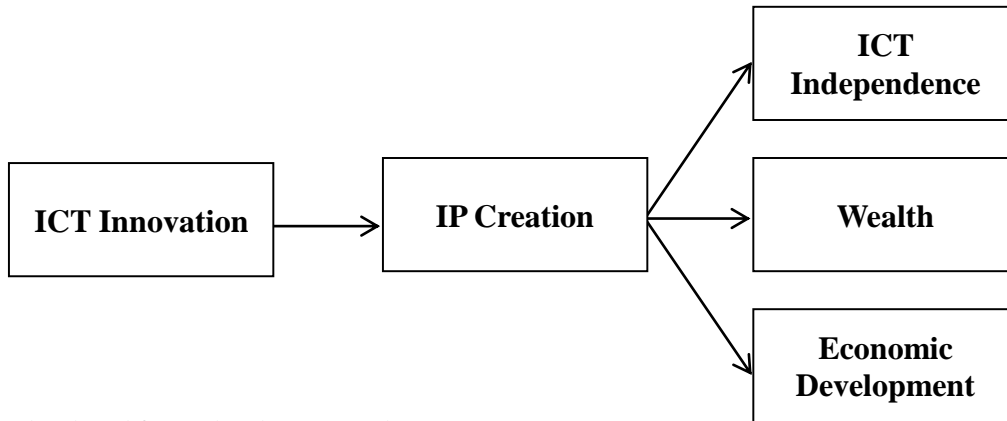
6.0 DISCUSSION

6.1 The Impact of Intellectual Property

6.1.1 Enabling access to physical inputs to innovation development

Through evidence presented in the case, a motivator for indigenous ICT innovation is to ultimately create IP. The Bangalore Declaration, drafted by Simputer innovators (GV, 1998) and outlined in Table 1, states that “latent intellectual talents in a developing country should be harnessed to create monetarised intellectual property in I.T., as this can lead to the rapid generation of wealth” (Chandru & Manohar, 1998a, p. 2). Additionally, the Declaration begins by stating that “[I.T.] presents developing countries with a historic window of opportunity that enables them to create national wealth and break the cycle of poverty and dependence” (Chandru & Manohar, 1998a, p. 1). This brings together the following flow of motivations from the viewpoint of the Simputer's innovators, as presented in Figure 2.

Figure 2: View of ICT Innovation and IP by the Simputer's Innovators



Source: developed from Chandru & Manohar (1998a)

The Declaration places the context for these activities at the macro (national)-level, and therefore in the case of India: Indian ICT Innovation leads to the creation and amassing of Indian monetarised IP, creating wealth in India, increasing India's economic development, and breaking free from both poverty and ICT dependency on developed economy ICT providers. Most notably, the Declaration states that “intellectual property will be the yardstick for assessing the wealth of nations” (Chandru & Manohar, 1998a, p. 1). To the Simputer's innovators, creating IP has become a global norm, a duty, something which Indians must do for the nation to be recognized as wealthy and developed on the world stage. Although IP was earlier conceptualised as a regulative institution, IP has indeed taken on the characteristics of a normative institution, presenting a new finding. IP therefore plays a highly influential and indeed motivational role, which can be seen as contributing to the Simputer's development, *increasing physical access to future innovation inputs*.

Evidence in the case provides support for **Proposition 1: IP enables ICT innovation, as potential economic rewards act as an incentive to innovate, increasing physical access to innovation inputs.**

PicoPeta's Amida Simputer consisted of core components leveraged from the DC, with the exception of the Alchemy window manager. Alchemy, developed by PicoPeta, was made proprietary in order to compete through differentiation from its competitor's offering (Manohar, 2008). Therefore, the protection offered through IP, specifically copyright for software, enabled PicoPeta to innovate and

compete to ensure commercial viability, therefore *increasing physical access to software as a future innovation input*.

6.1.2 Constraining access to physical inputs to innovation development

Evidence from the case provides support for **Proposition 2**: *The expansion of IP's scope and duration constrains ICT innovation as physical access to innovation inputs is decreased, through increasing restrictions on access and use of ICTs*. Although there is no evidence of IP's expansion in duration as decreasing access to innovation inputs, the case does present such evidence for IP's scope.

TRIPS was previously seen to expand copyright protection to cover both software source and object code (WTO, 1994). During the second phase of the Simputer's development, software developed by PicoPeta, specifically the Alchemy window manager, was proprietary (Amida, n.d.c). In the previous discussion of Proposition 1, it was seen that IP offered the protection necessary for PicoPeta to innovate in order to compete, producing the Alchemy window manager as an innovation output, increasing physical access to software as a future innovation input. However, copyright protection, without the addition of an open license, also leads to a *decrease in physical access* in the case of software should it be released as object code only, without the software's source code, as was the case for the Alchemy window manager (Amida, 2004). In 2007, Alchemy's source code was released under the GNU GPL, with one of the reasons for this being a response to an increasing demand (Noronha, 2007), therefore providing evidence of the awareness of a decreased access to future innovation inputs.

6.2 The Impact of the Digital Commons

6.2.1 Enabling access to physical inputs to innovation development

The case provided evidence for **Proposition 3**: *The DC enables ICT innovation by lessening restrictions on access and use of software, thereby increasing physical access to innovation inputs*. The first phase of the Simputer's development demonstrated that the DC was drawn on exclusively for

software to be used as innovation inputs. The core, as stated, was the GNU/Linux operating system, licensed under the GNU GPL (ST, 2000e). The remaining main software components used as innovation inputs in the first phase are confirmed to be from the DC, under the GNU GPL. While there is less information about the second phase with respect to FLOSS as innovation inputs, the core, GNU/Linux, is confirmed.

The rights granted through the GNU GPL license, specifically the lessening of restrictions on access and use imposed by IP (GNU, 2008b), allowed the Trust to leverage significant existing innovations, and to make changes to suit their purposes. The Trust's FAQ states: “[t]o write these from scratch would make it infeasible to even conceive of such a project” (ST, 2001b, no.32), demonstrating that, in the case of the Simputer's innovation, it would not have happened had it not been for the DC. In addition, all software developed by the Trust in the first phase was put under the GNU GPL, while all modified versions of GPL software remained under the GPL, due to this being a requirement of the license (GNU, 2008b), maintaining the same rights to future innovation inputs from which the Trust originally benefited. Specifically, the GNU GPL allows anyone to run, modify and redistribute software source code, for commercial or non-commercial purposes (GNU, 2008b; GNU, 2008d), demonstrating that the DC *increases physical access to software as innovation inputs*.

6.2.2 Constraining access to physical inputs to innovation development

The findings lend the understanding that the DC enabled physical access to innovation inputs (GNU/Linux) which facilitated the Simputer's innovation. However, constraints can be seen upon examination of the software input to the Simputer's innovation which was not taken from the DC: the Alchemy window manager. Alchemy was built from scratch and made proprietary, in order to differentiate PicoPeta's Amida Simputer from Encore's offering (Manohar, 2008). Building an application of Alchemy's importance, which was a building block for other Amida Simputer

applications (Amida, 2004), can be seen as a significant undertaking, when contrasted with physically accessing and adapting existing software applications from the DC.

Could the DC have offered PicoPeta increased access to innovation inputs, yet restrict Encore's physical access to their innovation outputs? If PicoPeta wished to access and adapt existing software from the DC, as a way to decrease their transformation costs, it could access FLOSS either in the public domain or under an open license. First, the public domain would have allowed access, adaptation, and release of the object code only, in a proprietary manner (CC, n.d.; FSF, 2008a). However, the amount of FLOSS in the public domain is limited as the majority is copyrighted, and under an open license (FSF, 2008a). Second, in absence of limited innovation inputs from the public domain, PicoPeta could turn to open licensed FLOSS, with the central license being the GNU GPL (Benkler, 2006). However, copies and modified software under the GPL must remain under the GPL (GNU, 2008b), enabling physical access to the source code by Encore, with PicoPeta unable to include an additional term disallowing commercial use of the software in order to restrict Encore's use (GNU, 2008a). Due to the limited FLOSS in the public domain, the restrictions imposed by the GNU GPL to keep software at a high level of accessibility, PicoPeta encounters *decreased physical access to software as innovation inputs* in order to pursue its differentiation strategy, suggesting a new finding. There was no evidence in support of **Proposition 4**: *The DC constrains ICT innovation through technical infrastructure challenges in developing economies, decreasing physical access to innovation inputs.*

7.0 CONCLUSIONS

This research set out to respond to the question: *How do the meta-level institutions of intellectual property and the digital commons impact – contribute or restrict – ICT innovation in developing economies?* To respond to this question, IP (particularly copyright) and the DC were conceptualised as

meta (global)-level institutions, increasing and decreasing ICT innovation process transformation costs through respectively decreasing (closing) and increasing (opening) physical access to innovation inputs. As a specific case through which to seek answers to this question, the Simputer's innovation was analysed. The following is an overview of the research's findings:

- ⑩ It was seen that IP, acting as a normative institution, motivated ICT innovation, decreasing transformation costs through increasing physical access to innovation inputs. IP similarly motivated ICT innovation through offering economic rewards.
- ⑩ IP and the DC, when working together with IP providing the copyright and the DC opening rights granted by copyright, achieve open licensing and decrease transformation costs through increasing physical access to innovation inputs. However, when working apart, IP alone increases transformation costs through decreasing physical access to innovation inputs, demonstrating the institutions as counterbalancing.
- ⑩ The evidence suggests that the DC did not provide support for a competitive strategy reliant on restricting access, increasing transformation costs through decreasing physical access to innovation inputs.

These findings denote a number of implications to ICT policy and research. Regarding ICT policy, this research points to the importance of developing economy ICT policy makers to first, address the influence of meta-level institutions which constrain innovation, as a process contributing to economic development, and second, to support those which enable it. First, the constraining influence of IP is known to developing economy policy makers. In 2004, Argentina and Brazil made a proposal to WIPO for the establishment of a Development Agenda, in order for the organisation to act in the broader interests of development (WIPO, 2004a). The proposal has since been supported through a Committee on Development and IP (CDIP), among other initiatives (WIPO, 2008). This research underlines the importance of both developed and developing economy policy makers to coordinate efforts supporting

WIPO's Development Agenda through the CDIP.

Second, this research adds to the existing evidence calling on ICT policy makers to support the DC, as an institution enabling ICT innovation granting developing economies the opportunity to move beyond being consumers to become active producers in the current information economy. As Sen (1999, p. 75) notes, the “capability to function” is what really matters to the poor and non-poor person; hence the reduction of barriers to ICT innovation is a key contributor towards economic development. This additionally echoes the calls of a supporting document to the Bangalore Declaration which had advocated that the Indian central government should invest in supporting DC software (Chandru & Manohar, 1998b). How ICT policy can support the DC is highly contextual, however guidance can be sought from the work of the Association for Progressive Communications (APC), and the International Open Source Network (IOSN), a United Nations Development Programme (UNDP) initiative, which have both been leaders in informing developing economy policy-makers of strategies in support of FLOSS (APC, n.d.; Wong, 2004).

Concerning the implications to research, three interrelated contributions can be identified. First, it has contributed to those gaps outlined in the introduction: the impact of institutions in the developing economy context and ICT innovation, as a form of production, has been studied; and overall a contribution has been made to understanding the meta-level institutional impacts on ICT innovation in developing economies. Second, this research is one of the few research efforts, if not the first, which has conceptualised IP and the DC as institutions, drawing on the NI and NIE body of theory. The research has contributed a framework of meta-level institutions impacting ICT innovation and propositions that can be a starting point for future research. The emergence of the DC as an institutional form in literature is new, emerging in the work of Benkler (2002, 2006), while we remain unaware of other conceptualisations. Additionally, while transaction costs are at the core in NIE (North, 1990; DiMaggio & Powell, 1991; Williamson, 2000), North's (1990) conceptualisation of

transformation costs applied to ICT innovation development is a new contribution. Third, a last contribution is a new finding from the Simputer's analysis, that IP, though initially conceptualised as a regulative institution, had taken on the characteristics of a normative one through motivating the Simputer's ICT innovation in order to create IP, and to ultimately achieve economic development.

Notwithstanding these implications, the limitations of the research are the premise for future research directions. In terms of data sources, future research may include actors in Simputer innovations, those who had accessed outputs of the Simputer's innovation, and used these as inputs to their own innovations. It is also recommended that additional ICT innovation processes in developing economies be examined to gain an understanding of how the findings in this study compare to other ICT innovations in other developing economy contexts. Further, future research should also investigate the research's finding that IP creation motivates innovation, as suggested above, for its generalisability, especially as it is a new finding, not previously emerging in reviewed literature.

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APPENDIX A: DEVELOPING ECONOMIES RANKED BY EXPORTS OF ICT GOODS AND SERVICES

Table A displays the developing economies from the top 50 economies in terms of exports of ICT goods and/or services in 2005.

Table A.1: Top 50 Developing Economy Exporters of ICT Goods and/or Services

Rank Goods	Rank Services	Economy	HDI	2005 ICT Goods Exports	2005 ICT Services Exports	2005 ICT Goods and Services Total
2	1	<i>United States</i>	<i>high</i>	154 917	184 691	339 608
1	17	China	medium	235 167	26 594	261 761
38	8	India	medium	1 424	41 659	43 083
14	30	Thailand	medium	26 169	5 510	31 679
16	49	Philippines	medium	24 418	1 225	25 643
26	32	Indonesia	medium	7 911	4 729	12 640
32	39	Turkey	medium	3 395	2 491	5 886
135	31	Lebanon	medium	n/a	4 870	4 870
158	34	Nigeria	low	n/a	3 415	3 415
43	44	South Africa	medium	798	1 786	2 584
45	45	Morocco	medium	705	1 659	2 364
80	40	Egypt	medium	14	2 350	2 350
54	50	Ukraine	medium	302	1 192	1 192

Source: developed from UNCTAD (2007: Table 2.11, Table 2.14); UNDP (2007)

It is therefore seen that 12/50, 24 per cent, of developing economies are in the top 50 exporters of ICT services while 8/50, 16 per cent, of developing economies are in the top 50 exporters of ICT goods.

APPENDIX B: DEFINITIONS OF 'INSTITUTION' BY INSTITUTIONALISTS AND INSTITUTIONAL EXAMPLES

Table B.1 demonstrates interpretations of institutions by institutionalists, demonstrating variation, yet considerable commonality, in interpretations.

Table B.1: Definitions of 'Institution' by Institutionalists

Definition	Author	Author's Discipline ¹
"... [A]n institution is any standing, social entity that exerts influence and regulation over other social entities as a persistent feature of social life, outlasting the social entities it influences and regulates, and surviving upheaval in the social order."	Hughes (1939, cited in King et al., 1994, p. 141)	sociology
"Institutions are the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction. In consequence they structure incentives in human exchange, whether political, social, or economic."	North (1990, p.1)	economics
" <i>Institution</i> represents a social order or pattern that has attained a certain state or property."	Jepperson (1991, p. 145)	sociology
"Institutions consist of cognitive, normative, and regulative structures and activities that provide stability and meaning to social behaviour. Institutions are transported by various carriers – cultures, structures, and routines – and they operate at multiple levels of jurisdiction."	Scott (1995, p. 33)	sociology
"... [I]nstitutions – organized patterns of socially constructed norms and roles, and socially prescribed behaviours expected of occupants of those roles, which are created and re-created over time."	Goodin (1996, p. 19)	philosophy
"Institutions are devised by individuals, but in turn constrain their action. They are part of the broad social fabric, but also the medium through which day-to-day decisions and actions are taken. Institutions shape human action, imposing constraints whilst also providing opportunities." ²	Lowndes (1996, p. 182)	governance
"Institutions are sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals and groups."	Edquist & Johnson (1997, p. 46)	economics

¹While several definitions are influenced by the author's discipline, a number of authors, namely North, Goodin, and Edquist & Johnson, can be perceived as representing a multi-disciplinary perspective.

²Lowndes (1996, p. 182) also includes two other components to her definition: "Institutions have formal or informal aspects" and "Institutions have legitimacy and show stability over time".

Table B.2 lists illustrative examples of informal / normal and formal / regulative institutions, while Table B.3 lists institutions identified in the literature at the meta (global)-level which impact ICT innovation.

Table B.2: Examples of Informal / Normative versus Formal / Regulative Institutions

Formal / Regulative	Informal / Normative
written rules laws constitutions legislative procedures contracts property rights international regimes	conventions codes of conduct behavioural norms customs societal norms and duties traditions routines

Source: developed from Colson (1974 cited in North, 1990); North (1990); DiMaggio and Powell (1991); Scott (1995); Lowndes (1996).

Table B.3: Meta-Level Institutions Impacting ICT Innovation

Formal / Regulative	Informal / Normative
International property agreements Commons International investment agreements International trade agreements International R&D programmes International technical standards Market structures: FDI, MNCs and SMEs	Technological trajectories: “pace and direction of technical change” (Mytelka 2000: 19)

Source: developed from Archibugi & Michie (1997a); Edquist (1997); Edquist & Johnson (1997); Mytelka (2000); Benkler (2006).