The Rural ICT Investment Design Framework
- Case study on Rural Nepal Communities

Hyunjung Lee[1] and Jeong-Dong Lee[2]

Abstract

The paper aims to identify the necessary elements to be assessed to develop a better ICT investment design framework with a special focus on the trilateral linkage between ICT, innovation and growth for poverty reduction and rural development. This linkage is particularly important to address a variety of challenges and obstacles of developing countries, mainly lack of complementary resources, such as telecommunications and other necessary infrastructure, education and technical skills, which would hold back potential benefits from the ICT.

This paper also provides a real case study using the survey data of thousands rural households in Nepal. Several characteristics of the case study are: Firstly, statistical analysis is applied to assess the ICT needs and innovation capabilities of rural communities. Secondly, the willingness-to-pay (WTP) is analyzed together with various characteristic variables using Heckman's 2-stage method. Lastly, the suggested ICT investment design framework is presented. With the real case, all the results contained in the study are expected to shed a light on the appropriate process of ICT investment design for the rural community development in developing countries.

[1] Hyunjung Lee, ICT Specialist/Economist of Asian Development Bank (ADB); hjlee@adb.org
[2] Jeong-Dong Lee, Associate professor of Seoul National University of Korea; leejd@snu.ac.kr

1. Introduction

Information and communication are indispensable ingredients in people's decision making and empowerment to improve their wellbeing and livelihood. Information and communication technology (ICT), as a tool to handle and communicate information, is increasingly integrated with every aspect of business, life and society by serving various economic, social, financial, and educational needs. Both established ICT (radio, television, and video) and new ICT (cell phones, computer, and the internet) have been applied to and integrated with the full range of human activity.

Since 1980s, various researchers have attempted to verify those impacts of ICT in terms of contribution to gross domestic product (GDP) growth through labor productivity increase and capital deepening using endogenous growth model and production methods. Those researches reveal that this growth effect rather comes from the uptake and the utilization of ICT in business and society than from the productivity increase of ICT sector itself. It was also emphasized that the realization of the intended benefits of ICT requires the presence of a complex set of complementarities such as economy's adaptability, resource endowments, human capacities, and institutional framework.

However, a few literatures have yet paid attention on linkage between ICT and poverty reduction and innovation despite ICT can directly contribute to poverty reduction and change the dynamics of innovation by reshaping the way of interacting and exchanging ideas among economic agents,

Chronic impoverishment, particularly in rural areas, is often related to limited access to market and job information and learning opportunities and constrained by poor infrastructure such as road and power. Rural farmers reply on rudimentary outdated information for farming practices and have limited marketing and sales opportunities for agricultural products. Rural children have greater difficulty attending school and, when they do, they stay for shorter periods, leaving with fewer qualifications and are less likely to proceed to further education, either technical or higher education. Public services including health care and administration are usually centered in urban areas.

ICT also helps a formation of a knowledge stocks, facilitate human interaction and interactive and collective learning activities through mobile or internet, supporting

other development related applications. This aspect of ICT contribution poses great significance in the context of rural communities and developing countries because of their primary binding constraints for development – lack of productive assets in terms of both financial and human capital as well as high cost of transaction and interaction caused by their isolation and poor infrastructure.

Therefore, the benefits of ICT should be captured not only from an increase in connectivity or broader access to ICT network per se but also from the facilitation of new types of economic opportunities as well as the promotion of innovation. Simple provision of ICT as a technology will not substitute for addressing the deeper economic, social, resource and other challenges unless accompanied by the development of a complementary set. In the same line, simply measuring the presence or absence of ICT needs in a given country or region will not tell us about how much ICT investment would be required and what role ICT could play in addressing the development challenges.

In view of this, the paper aims to identify the necessary elements to be assessed to develop a better ICT investment design framework with a special focus on the trilateral linkage between ICT, innovation and growth for poverty reduction and rural development. While there are mixes of too optimistic and too skeptical views on the role of ICT for development, both conceptual and empirical research has not been conducted to investigate this linkage particularly for developing countries. Therefore, the paper will (i) conceptualize a trilateral linkage between ICT investment, economic growth and innovation through an extensive literature review; (ii) present a case study which assessed information needs and innovative capacities of rural communities and quantify rural households' willingness-to-pay (WTP) of ICT in Nepal; and (iii) finally suggest a ICT investment design framework.

2. ICT, Growth, Innovation, and Poverty Reduction

2.1 ICT and Growth

For developed countries, there is a widely accepted consensus that ICT exerts positive impact on economic development. The productivity paradox dubbed by Solow has been mostly resolved with empirical evidences at various levels of organization, industrial sectors, and country. Numerous studies have examined the economic impact of ICT at the macro-economic level (Colecchia and Schreyer, 2002; Jorgenson, 2003; Jorgenson and Stiroh, 1999; Jorgenson and Vu, 2005; Oulton, 2002; Schreyer, 2000; van Ark et al., 2002). These studies show that ICT investment contributed to capital deepening and growth in most OECD countries in the 1990s, though with considerable variation across countries. Many policy-makers and researchers have agreed the strong performance of the U.S. economy in the late 1990s as most welcome evidence for the view that the large investments in ICT have finally started to pay off (Timmer and van Ark, 2005; Colecchia and Schreyer, 2002; Jorgenson, 2001; Jorgenson et al., 2003b; Jorgenson et al., 2003a; Oliner and Sichel, 2000).

Several studies have also been undertaken at the industry level (Pilat and Lee, 2001; van Ark et al., 2002; van Ark et al., 2003; Stiroh, 2002) and some emphasized the performance of ICT-using sector, composed of industries that are intensive users of ICT. Studies along these lines show that ICT-using services in the United States and Australia experienced an increase in productivity growth especially in the second half of the 1990s, which seems partially associated with their use of ICT. Few other countries have thus far experienced similar productivity gains in ICT-using services (OECD, 2003a).

The evidence emerging from firm-level studies suggests that the use of ICT does have positive impacts on firm performance and productivity, even in countries and industries for which little evidence is available at more aggregate levels of analysis (Brynjolfsson and Hitt, 1996; Becchetti et al., 2003; OECD, 2003b; Hempell, 2005). However, these impacts occur primarily, or only, when accompanied by institutional changes and human capital investments. For example, many empirical studies suggest that ICT primarily benefits firms where skills have been improved and organizational

changes have been introduced (Brynjolfsson and Hitt, 2000).

United Nations Conference on Trade and Development (UNCTAD) study (2006) shows that a 1% increase in the ICT index of a country resulted on average in a 0.1% increase in per capita GDP in 1996 and in a 0.3% increase in 2003. According to OECD Productivity Database dated September 2005, average contributions of ICT investment to GDP growth is 0.55% during 1995-2003 and OECD countries shows that similar ICT investment would contribute to 0.2 – 0.9% of GDP growth. Roller and Waverman (2001) study using 21 OECD countries data provides evidence of a significant positive causal link between telecommunication infrastructure and economic growth, especially when a critical mass of telecommunication infrastructure is present. In the case of developing countries, the context of ICT investment is different.

However, for developing countries, the arguments are not so affirmative. For example, Dewan and Kraemer (2000) and Pohjola (2002) have found a strong relationship between ICT and productivity in developed countries, but not in developing countries in their cross country comparison. Some literature found a critical mass of ICT stock and conditional factors such as human resource and traditional tangible capital stock are necessary to get benefit out of ICT investment. Also a numbers of empirical studies have indicated various constraints to block the benefit of ICT for economic growth and development (Kraemer and Dedrick, 1994; Forestier et al., 2002; Kiangi and Mshigeni, 2002; Maung and Harindranath, 2004). For example, Alcántara (2001) stated "*…The likelihood that people in low-income countries can improve their life chances is often sharply limited not only by their lack of access to modern means of communication and sources of information, but also by a complex network of constraints ranging from unresolved problems of poverty and injustice in their own societies to the structure and dynamics of the global economic system*". Most developing countries have similar obstacles and lack of resources, such as basic physical infrastructure including power, education and technical skills, which frequently mentioned as major constraints for the development, in general, and benefit of ICT, in particular.

Even with lack of positive empirical evidence on the benefit of ICT investment and despite various challenges and constraints in developing countries, a large number of international institutes has been initiating ICT development project under the premise that

ICT investment will eventually bring positive effect on the social development of recipient countries. World Summit on the Information Society (WSIS) posed range of issues of ICT development including accessibility, affordability, application development, and capacity building at all levels of society. 'Global Alliance on ICT for Development' initiated by UN is another example of international project (UN, 2006). Sachs and McArthur (2005) pointed the significant role of ICT to achieve Millennium Development Goals (MDGs).

2.2 ICT for Rural Development

Rural community is located far from an economic center and they are lacking from the basic needs like food and water but also from the opportunities that may enable them free of poverty. ICT cannot provide food and water but can provide the access to information, services, and opportunities that wouldn't be possible through conventional channels. International development agencies, such as Asian Development Bank (ADB), the World Bank, and various UN agencies suggest that easily accessible information fosters knowledge formation that can induce empowerment for rural community development (ADB, 2001; OECD, 1989; Hanna, 1994; United Nations ICT Task Force, 2003; Sachs and McArthur, 2005). Also private companies, local governments and non-governmental organizations (NGOs) have been implementing various ICT projects to contribute for the rural community development.

Basically, all these projects and activities expect numerous benefits and opportunities from the ICT provision in rural communities in both micro and macro levels including time and cost savings and increased economic opportunities through telecommuting, telemedicine, market and job information service, distant learning, e-government service and etc. It has been expected that ICT would enable the poor to access to (i) information about markets, prices and business opportunities, (ii) information on employment and enterprise development, (iii) skills and education through delivery of both formal and informal e-learning, (iv) innovative e-health care and

information, (v) more efficient and transparent e-government services,[3] and (vi) improved communications and channels for grievances and complaints. Also it has been expected that ICT would contribute to the enhanced knowledge accumulation and sharing, enhanced formal and informal networking, to name a few in rural communities (Hanna, 1994; Mansell, 1999; Bhatnagar and Schware, 2000). However, the outcome of most projects in rural area has not been evaluated as successful as expected, mainly because of the sustainability issues. In some cases the revenue runs short of required expenses. In other cases the usage rate goes well below the expected level, when service contents do not match with the local needs.

2.3 ICT and Innovation

The role of technological progress has been key driver to any economic growth for many decades, and innovation has become a key concept for the development plan. The term, innovation, may refer to both radical and incremental changes to products, processes or services and includes also the changes in intangible institutions such as rule, law, routine, the way of behavior, etc. (Tidd *et al.*, 2005; Furman et al., 2002; Hu and Mathews, 2005; Stern et al., 2000). Numerous studies have demonstrated how growth and innovation interact, including how institutions and incentives affect the scope and pace of technological innovation across countries (Aghion et al., 1998; Barbier, 1999; Chua, 1999; Hassink, 2002; Zhou and Xin, 2003).

Recently a policy report from World Bank recognized the role of innovation in development of developing countries (Aubert, 2005). The report indicated that the conventional policy prescription on development, known as Washington Consensus, the set of privatization, liberalization, and deregulation policies, demonstrated limitations for promoting sustainable growth in the developing world. Instead, it recommended the policies to promote innovation for development. Current consensus on the framework of development policy is that all policy frameworks should contribute to make the target region, community, sector, and/or nation innovative (Aubert, 2005; Yusuf and Evenett,

[3] Public service includes birth/death/marriage registration, education, employment opportunity, health (places/treatment), land (registration/taxes), finance and tax, justice, procurement, post and customs, and others.

2002). Unfortunately, the innovation system, which comprises all important economic, social, organizational, institutional, and other factors that influence the development, diffusion, and use of innovation, is ill-prepared in developing countries. Aubert (2005), for example, specified three main areas of obstacles such as poor business and governance conditions, low educational levels, and mediocre infrastructure.

Previous literature of innovation system has stipulated components of strong innovation system in different level, such as national, sectoral, and regional, etc. (Edquist, 2005). Based on those discussions, the followings are identified as key factors for innovative community development; (i) information sharing regarding input and output market; (ii) exposure to state-of-the-art technologies; (iii) strong institutional arrangement with efficient policy delivery; (iv) strategic investment for future growth.

Individual community might have diverse needs in terms of components of innovation system depending upon the context. In agri-business dominated community, for example, the information of market price of its agricultural products and that of job opportunities are all important for their revenue potential. At the same time, pooling of indigenous knowledge and/or absorbing outside technologies are important for upgrading the production process. Public services ranging from weather forecasting service to various extension programs should be delivered efficiently in order to support the private activities. More importantly, investment for human resources, physical capital and infrastructure should be maintained to augment the future potential of growth. All these components should be expected to make a community upgrade its innovative capacity. The logic behind the innovation system leads us to expect the community will get more income and will have more potential to achieve social needs.

ICT can provide great opportunities for the formation of a knowledge stocks which are basis for all the components of innovation system. For example, in rural communities, indigenous knowledge tends to relate to the local know-how and traditional techniques and often non-documented and held by local communities. Although this knowledge is vast but limited to access. ICT can also re-enforce human interaction and interactive and collective learning activities through an advanced communication such as e-mail and community networking systems that could provide sharing and broad access to data and information among community members, which are crucial for further

development of common perspectives and objectives for the community. Furthermore, other applications that are likely to support development priorities benefit from a well-functioning ICT infrastructure. For example, public-sector applications including distance learning and professional development, road traffic management, disabled support services, air traffic control, healthcare, electronic tendering for contracts and public administration applications require reliable networks. Finally, ICT has potential to build strong policy distribution system that enables public sector efficiency "one stop shopping" for government information, applications designed to limit environmental degradation, citizen and emergency support services, and services to support inter-community meetings (Mansell, 1999).

3. Case Study – Needs Assessment and WTP Analysis in Nepal

In view of the trilateral linkage between ICT, innovation and growth, this session presents the case study using ADB-administered survey carried out as part of the needs assessment for planning ICT infrastructure and content development in rural area in Nepal in 2007. [4] This case study focuses on three areas: (i) Nepal's ICT development situation; (ii) ICT needs and innovative capabilities of rural communities; and (iii) WTP for ICT services of rural communities.

3.1 Nepal's ICT Development

Nepal is one of the geographically challenged countries with about 25.3 million people scattered throughout mountains, high peaks, hills, valleys and terai, which present formidable barriers to sustainable growth and development - a GDP per capita of $311 (FY 2006), an average growth rate of 2.9% during the past three years, and a poverty incidence of 31% (2004). Rural population dominates in Nepal with around 15 percent of the total population accounted for by urban cities. Although contributions of non-agricultural activities are gradually increasing in GDP, agriculture still remains Nepal's principal economic activity, employing over 80% of the population and providing 38% of

[4] The analysis for case study is separately made and any results in this paper do not reflect the views of the ADB.

GDP.

Although Nepal has achieved a penetration rate of 6.48% on a national scale, with fixed telephone at 2.46% and mobile at 4.03%, it is very much skewed in favor of Kathmandu and coverage of rural areas, with a penetration rate of 0.06%, leaves much to be desired. More than approximately 40% of rural districts have no telecommunication services. Currently, four companies provide telephony services in the country such as the state-owned incumbent operator, Nepal Telecom (NT) and three private operators such as United Telecom Ltd. (UTL)[5], STM Telecom Sanchar Pvt. Ltd. (STM)[6], and Spice Nepal Pvt. Ltd. (SNPL)[7].

Table 1. Nepal's Core Indicators

Indicators	Nepal	Low Income Countries	Asia
GDP per person 2005	271	1,320	3,391
GDP % Growth (constant dollars 2005)	2.5	N/A	5.2
Government as % GDP	17.4	N/A	35.0
Effective teledensity	1.79	7.93	23.43
Percent of pupils finishing grade 5 (00-04)	67	N/A	80
Literacy rate for 15-24 year olds (00-04)	70	N/A	91
Public phones per 1000 persons	0.09	1.1	8.52
Telephone Tariffs US$ (% of GDP/cap)	25 (12.0%)	48 (11.4%)	62 (2.5%)
Internet users per 100 persons	0.83	4.22	9.69
PCs per 100 persons	0.47	1.46	6.42
Broadband subscribers / `000 persons	0.00	0.83	23.23
International bandwidth bits per person	1.7	12.6	159.0
Internet traffic US$ as % GNI per capita	38.93	190.07	20.89

Source: MIS Report, Issue 14, Nepal Telecommunication Authority, Feb. 2007; ITU Measuring the Information Society 2007; UNESCAP 2007; UNCTAD 2007; ADB estimate

Nepal has around 4,000 Village Development Councils (VDCs). Under the Special Rural Telecom Program, NT has utilized the VSAT technology and provided 786 telephone lines in 216 VDCs in the remote mountainous regions. 534 VDCs in Eastern Development Region have received at least 2 public call offices (PCOs). The NT has around 2,000 PCOs around the country. For the promotion of rural telecommunication,

[5] UTL was licensed in 2002 to provide basic telephone service based on WLL technology for the entire country. UTL, presently, has no presence in rural areas.

[6] STM was licensed in 2003 as a rural telecom operator only for the Eastern Development Region.

[7] SNPL was licensed in 2004 to provide GSM based Mobile telephone service for the entire country. SNPL, presently, has no presence in rural areas.

the NTA has managed Rural Telecommunication Development Fund (RTDF), with contributions from a 2% tax on all licensed operators including internet service providers (ISPs) since 2000.[8]

Table 2. Nepal's Rural Connectivity

Region	Total VDCs	VDCs Served with at least one PCO		% of VDCs Served with at least one PCO*
		NT	STM	
Country	3,915	2,028	516	51.8% (NT); 2.9% (STM)
Eastern Development Region	893	465	516	52.1% (NT); 57.8% (STM)
Central Development Region	1,199	605	-	50.47 % (NT)
Western Development Region	865	535	-	61.92 % (NT)
Mid-Western Development Region	575	226	-	39.30 % (NT)
Far-Western Development Region	383	197	-	51.44 % (NT)

*Because of possible overlap between NT and STM coverage, the two figures can not be added up.
Source: MIS Report, Issue 14, Nepal Telecommunication Authority, Feb. 2007

Nepal's internet market was dramatically boosted in mid-1999 when ISPs were allowed to have their own international gateways, and the use of very small aperture terminal (VSAT) was liberalized. The NT has established internet presence in 59 of the 75 districts, allowing its users internet connection with local dialing. The price of internet service fell to $0.2 per hour, the lowest in South Asia. As of February 2007, of the 39 licensed, 31 internet service providers (ISPs) are operational and serve around 210,000 users (0.83% penetration) mostly inside Kathmandu. To boost rural ICT and reduce digital disparity, the Government of Nepal is recently set to drastically reduce license fees on VSAT users and ISPs keen on operating services in rural areas.[9]

3.2 ICT needs and Innovative Capabilities of Rural Communities

The survey is made for different districts[10] spreading over the whole Nepal and

[8] The Fund currently amounts to about NRs 520 million (US$8.5 million) and approximately provided NRs 200million to NT for rural telecom development, under which NT is undertaking to provide at least 2 public phones to all the VDCs.

[9] License fee to open an ISP in rural areas will be set at NRs. 100 for five years with a renewal fee of NRs. 90. VSAT license for rural areas, Education and Health institutions will be reduced to NRs. 100

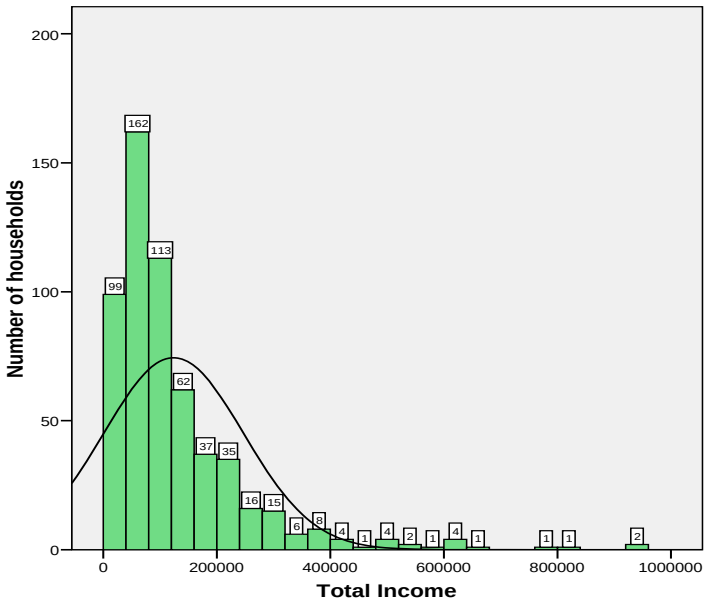
[10] The following districts are included (i) Sunsari (Tarai-Eastern Development Region); (ii) Solukhumbu (High hill-Eastern Development Region); (iii) Kathmandu, Lalitpur and Bhaktapur (Central Development

the sample is constructed based on random sampling methodology. The size of the sample is 578 households and the total number of people involved is 3,196.

3.2.1 Household Income Distribution

The income level of surveyed households is summarized in Figure 1, which shows highly left-skewed distribution. Approximately 36% of people work outside of the village. As a source of house income, among the economic activities, cultivation takes 31.4%, salaried 25.5%, earning abroad 13.6%; and business and trade 11.4%.

Figure 1. Distribution of household income



3.2.2 Information and Communication Needs and Modes

As Table 3 shows, the share of expenditure on fixed and mobile communication is in average of 6 % out of a total of household expenditure across three income groups. This is much higher than the average of 15 OECD countries of around 2%. Korea is one of the exceptional OECD countries, which amounts to 6.5% in 2005. Given that the food

Region); (iv) Myagdi (Hill and Remote- Western Development Region); (v)Dang (Chure Bhawar – Mid Western Development Region); and (vi)Achham (Hill and Remote – Far Western Development Region)

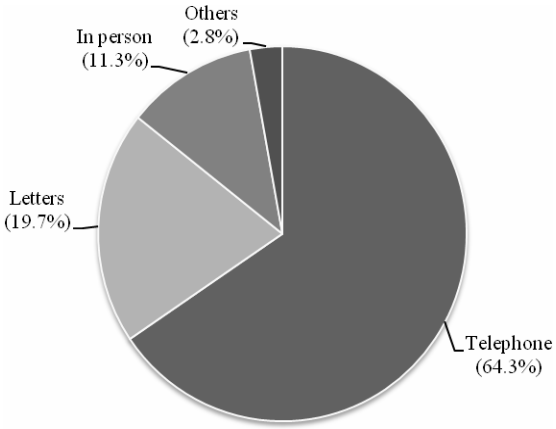
takes most of expenditure, more than 6% of communication expenditure share seems to indicate the significance of communication in people's life in rural Nepal. Therefore, we expect a small improvement in communication infrastructure and service would lead to substantial net gains for individual household.

Table 3. Composition of household expenditure (%)

Categories of expenditure (%)	Lower income group (n=188)	Middle income group (n=189)	Upper income group (n=189)
Food	69.46	61.39	48.92
Education	14.03	24.05	28.50
Health	8.94	6.4	9.45
Rent	1.73	3.11	5.24
Maintenance	1.67	1.98	4.82
Water	0.55	0.36	0.28
Electricity	3.61	2.71	2.80
Fixed and mobile communication	6.78	6.00	6.39

Among the various communication modes, telephone is used as an important mode of communication than other modes as shown in Figure 2. Given this trend, if more efficient, advanced, and diverse communication services are introduced such as voice over internet protocol (VOIP), e-mail, chatting, video conferencing and so forth, rural household would get much higher benefit.

Figure 2. Percentage of main modes of communication (%)



In the case of information needs, according to the survey, more than 52.6% of rural households need to visit more than twice to the nearest government office to complete transaction for public administration services. Around 15.9% of them need to visit more than four times to complete. In terms of time, 11.3% of them spent more than one day and 43.3% spent at least one hour. Since most of the public service transaction requires only a few minutes through internet, the provision of ICT will provide much benefit in terms of time and effort of households.

3.2.3 Physical infrastructure

About 80% of households are connected with electricity service and more than 70% of household are exposed to TV as Table 4 shows. High penetration ratio of TV and Ratio implies that households are receiving news and general information from outside of the community. The penetration ratio of telephone is low compared to TV and Radio but quite high compared to Nepal's national average penetration ratio. TV and Radio are all uni-directional (passive) communication medium, on the while telephone provides bi-directional (active) medium. The discrepancy in penetration ratio between these two mediums indicates that the household's needs for active communication might be high.

Table 4. Level of physical infrastructure

Items	Percentage of owners (%)

Electricity	79.6
Color TV	41.7
BW TV	29.3
Radio	78.1
Motor Cycles/Moped	10.5
Telephone	21.6

3.2.4 Human capital

Well prepared human capital is one of the key factors in both of successful IT adoption and innovation. In terms of general education level, only about 5% more percent people got university level education. Under this survey, 67% of people appeared benefited from education service at various levels as shown in Table 5.

Table 5. Education level

Non-educated	Educated (total: 67.8%)							
	Up to 4th	5th	6th-8th	9th-10th	11th-12th	Gra-duate	Post Gra-duate	Tech-nical
32.2	12.0	7.3	14.7	19.1	9.1	4.3	1.0	0.3

In terms of literacy, 52.2% of people surveyed can understand English and 71.6% of people understand Nepali, which might be quite high compared to other developing countries' cases. High education and literacy level signify that the rural communities in Nepal have well prepared human resources, in general. If adequate policies to promote ICT in the local situation are implemented, we expect innovative ideas of sophisticated ICT adoption and use might arise.

The computer literacy appeared to be very low: only 4.9% people can use in well versed way and 13.8% of people can use on average and minimal level. Remaining 79% of people cannot use computer. High English literacy rate with low computer literacy rate means that the lack of chance to use computer might be the main reason for low level of knowledge on computer. This finding, in turn, indicates that people can learn and use innovatively the computer, if computer becomes accessible.

3.2.5 Innovation Opportunities

ICT can be used in many ways ranging from e-mail with family members working outside community and access to internet to get information and learning. Public service through e-government system is another important area ICT can contribute much for the benefit of population. The concept of telecenter, which locates in village to cover basic ICT needs of the population in the village and facilitate various innovation opportunities, will be useful in this context with the help of public subsidy. Provision of public information and electronic transaction of public service may confer savings from the perspective of households and efficiency improvement from the perspective of government.

3.3 WTP for ICT in Rural Communities

3.3.1 Methodology

The survey has the question about the amount of money household can pay, i.e. WTP (willingness-to-pay), if the public service transaction is made through internet near their home, which implies the use of telecenter. 98.7% of households respond positively, which proves that there remain high needs unmet. The answered WTP may have some relationship with other variables that characterize the household or respondents.

Since there are mixes of household who wants to use internet and who does not want to use, simple OLS (ordinary least squares) with answered WTP as dependant variable and characteristic variables as independent variable might give biased estimates. To deal with this bias issue, we apply sample selection model of Heckman's 2-stage method.

In the first stage, we divide the whole sample into two groups who choose the service or not with the condition of $WTP > 0$ or $WTP \leq 0$, respectively. To estimate the factors which make WTP positive we used binary choice model. The independent variables, which affect the choice of the service, are divided into 6 categories, such as

personal characteristic (*char*), personal environment (*env*), experience of ICT system (*ICT*), experience of non-ICT system (*NICT*), regional dummy (*region*), and economic activity dummy (*job*). The binary choice model takes the following forms;

$$\Pr_i(yes) = \frac{e^{V_i}}{\sum_j e^{V_j}},$$

Where

$$V_i = \alpha + \beta_1 char_i + \beta_2 env_i + \beta_3 ICT_i + \beta_4 NICT_i + d_1 region_i + d_2 job_i$$

In the second stage, WTP value (*Y*) is regressed against the characteristic variables (*x*) based on Heckman's method, such that $Y_i = \beta' x_i + u_i$. The second stage regression is related with the first stage choice model by including the selection bias term (*selection*) is included, which is consists of joint distribution between binary choice model and second stage regression model. The independent variables are the same that are used in the first stage choice model, which gives the following form;

$$Ln(WTP)_i = \alpha + \beta_1 char_i + \beta_2 env_i + \beta_3 ICT_i + \beta_4 NICT_i + d_1 region_i + d_2 job_i + \delta selection_i + \varepsilon_i$$

3.3.2 Results

The first stage regression of choice model shows that the experience of telecenter made a negative impact on the choice of positive WTP. The other part of the survey showed that a large portion of the telecenter user was not satisfied with the services and some reported that existing ones offered not much useful benefits. This finding implicates that reorganization of the service packages should be made to match the households' needs. Other factors show the expected sign but not very significant. Even though, the positive estimates of the level of income and education and estimates of the dummies for electricity and phone are marginally insignificant, they implies that high income and educated people who are already enjoying the services of electricity and phone can actively use the telecenter.

Table 6. Result for the first stage regression of choice model

Variables		Estimates	Standard errors	P>|z|
Personal characteristic variable	Age	0.0709	0.142	0.618
	Age*age	-0.680E-3	0.00146	0.641
	Income	1.190E-5	7.940E-6	0.135
	Edu	0.299	0.190	0.116
Personal environment variable	Electricity	0.835	0.589	0.156
	Motor	-0.115	1.239	0.926
	Phone	1.398	0.902	0.121
Experience of ICT system	Telecenter***	-3.470	1.325	0.009
	Computer access	0.204	0.806	0.8
Experience of non-ICT system	No. of visit	0.366	0.358	0.306
	Travel cost	-0.00254	0.00420	0.545
	_cons	36.259		

Note 1: Number of observation = 301
Note 2: Adjusted R-square = 0.634
Note 3: Coefficients regional and job dummies are omitted to save the space

Table 7 shows the main results of WTP regression for the same set of explanatory variables. Two variables of level of education and dummy for phone use turn out to be positively affecting the amount of WTP. The results confirm again the importance of human resources to the incentive of telecenter use.

Table 7. Result for the second stage regression of WTP analysis

Variables		Estimates	Standard Errors	P>|z|
Personal characteristic variable	Age	-0.00509	0.0108	0.639
	Age*age	0.830E-4	0.000111	0.456
	Income	0.523E-9	0.211E-8	0.805
	Edu*	0.0305	0.0184	0.099
Personal environment variable	Electricity	0.0202	0.107	0.850
	Motor	-0.0404	0.0942	0.669
	Phone**	0.177	0.0695	0.012
Experience of ICT system	Telecenter	-0.0632	0.104	0.543
	Computer access	-0.0633	0.0653	0.333
Experience of non-	No. of visit	0.0282	0.0261	0.279

ICT system	Travel cost	0.000111	0.000161	0.491

Note 1: Number of observation = 301
Note 2: Adjusted R-square = 0.634
Note 3: Estimates for regional and job dummies are omitted to save the space

4. ICT Project Design Framework

ICT investment can be justified and ICT project itself can be sustainable when it is designed to contribute to innovation activity in the target area. The case study of rural communities of Nepal elucidates the potentials of ICT for innovation and provides implications for project design. The main findings can be summarized as follows;

Human resources are well prepared and investment for education is high: 67.8% of population has experience to get school service at various levels, and literacy levels of English and Nepali are 52.2% and 71.6%, respectively. Around 20% of household income is allocated to education. These numbers are impressive compared to those that can be found in other developing countries with equal development stage. Since human resource takes primary importance in innovation, the above findings implicates that if appropriate infrastructure, especially in terms of information network, is provided, the communities can make their own innovation.

Needs for active information sharing is high: 36% of population is working outside of the village. Cultivation is the main economic activity, and there are also other types of job taking significant share of income that require active information sharing, for example, earning abroad, business and trade, and so on. Cultivation itself has been known to be good example business that can benefit much from information sharing, of which examples include weather information, price for agricultural products, engineering and scientific knowledge for cultivation. Economic activity outside community entails exchange of information for job opportunity, money transfer, etc. These observations tell us that the communities feel strong needs for active information sharing which will support any kinds of innovative activity.

The mode of communication is not well developed: As a passive mode of communication, TV and Radio record high penetration ratio of more than 70%. Phone plays important role when they feel active communication needs, which results in more than 6% of expenditure share per household. Internet, known as most developed mode of two-way communication is not used well. The penetration ratio of computer is very low compared to other medium of communications and knowledge on computer is lacking; 79% of people do not know how to use computer. The above facts illustrate that the need for communication is high, but is not fully met with advanced mode, internet. If people are exposed to computer, the usage rate and pattern will develop high.

Public service provision is inefficient and WTP for efficient transaction is high: To complete public service transaction, 52.6% of households should visit physically more than twice and 11.3% of them is spending more than one hour. WTP turned out to be very high in that 98.7% of household reports that they will pay the telecenter service if it is provided efficiently. WTP analysis also showed that level of education and needs are positively correlated with high value of WTP. Household can get much benefit out of well designed public services for their business activity and for saving resources for public service transaction. Thus, the telecenter, if developed to match the needs of community, might provide platform to make the community innovative.

The above discussion regarding main findings from case study leads us to three design guidelines in terms of hardware, contents, and sustainability.

For *hardware design*, we have to remind that the case study shows that average household has enough needs to justify for the investment of their connection. In general, ICT project developer, in general, tends to focus on heavy users to rationalize the investment in short or medium term. Thus, telecenter should be designed to outreach to the maximum number of population by selecting appropriate location. Also the existing infrastructure of electricity and phone network should be utilized, if they can be used complementarily.

For *contents design*, we know that most of the e-government system focuses on the efficiency improvement of governmental process with minimal contents for business information. However, it is equally important to provide enough business related information together with governmental service. Furthermore, to exploit the benefit out of two-way communications of internet, knowledge uploading and sharing with peers, i.e. cyber community services, should be also embedded.

Sustainability design has been nagging issue in most of the ICT project in developing countries. Education to enhance the usage rate of implemented system has long been recognized one of the important tool for sustainability. Promotion of entrepreneurial activity regarding contents development and provision may be one solution to the sustainability problem. The case study shows that people are willing to pay the services if the contents satisfy their needs. Private entrepreneurs are always better than the public designer to identify the unmet needs and to develop innovative contents and delivery system. Thus, the concept of entrepreneurship should be every ICT project should embedded in the design.

5. Conclusion

Through the literature review, it is found that ICT has strong impact on economic growth but to a lesser extent on direct poverty reduction. In spite of issues related to measurement, data, and statistical models, the evidence of positive and significant productivity gains from ICT investment is still strong. However, ICT contribution to innovation has not been well recognized and fully captured, which can address a variety of challenges and obstacles of developing countries, mainly lack of complementary resources, such as telecommunications and other necessary infrastructure, education and technical skills, which would hold back potential benefits from the ICT.

Findings of the case study in rural Nepal communities show that the needs of ICT of multiple rural communities are quite diverse and enormous. Specifically, the needs assessment results tell us that ICT has much potential to make the communities innovative, but significant complementary efforts should be packaged together with ICT

provision, if its full benefit is realized. The willingness to pay analysis shows the variation and the extent of needs. Such analysis will serve as better evidence in support of policy formulation and investments design, particularly in the developing countries.

Reference List

Asian Development Bank. (2001) Toward E-Development in Asia and the Pacific: A Strategic Approach for Information and Communication Technology. Manila.

Aghion, P., Howitt, P., Brant-Collett, M., and García-Peñalosa, C. (1998). *Endogenous growth theory*. Cambridge, Mass: MIT Press.

Ahmad, N., Schreyer, P., and Wölfl, A. (2004). ICT Investment in OECD countries and Its Economic Impacts. In *The Economic Impact of ICT: Measurement, Evidence and Implications* (pp. 61-81). Organisation for Economic Co-operation and Development (OECD).

Alcántara, C. H. (8-1-2001). The Development Divide in a Digital Age. Geneva, United Nations Research Institute for Social Development (USRISD). USRISD Programme Papers on Technology.

Asheim, B. and Isaksen, A. (2002). Regional Innovation Systems: The Integration of Local 'Sticky' and Global 'Ubiquitous' Knowledge. *The Journal of Technology Transfer, 27,* 77-86.

Aubert, Jean-Eric (2005), "Promoting Innovation in Developing Countries: A Conceptual Framework". World Bank Policy Research Working Paper No. 3554.

Barbier, E. B. (1999). Endogenous growth and natural resource scarcity.. *ENVIRON RESOUR ECON, 14,* 51-74.

Becchetti, L., Bedoya, D. a. l., and Paganetto, L. (2003). ICT Investment, Productivity and Efficiency: Evidence at Firm Level Using a Stochastic Frontier Approach. *Journal of Productivity Analysis, 20,* 143-167.

Bhatnagar, S. and Schware, R. (2000). *Information tecnology rural development: Case studies from India* Washington, DC: World Bank.

Breschi, S. and Lissoni, F. (2001). Knowledge Spillovers and Local Innovation Systems: A Critical Survey. *Industrial and Corporate Change, 10,* 975-1005.

Brynjolfsson, E. and Hitt, L. (1996). Paradox lost? Firm-level evidence on the returns to information systems spending. *Management Science, 42,* 541-558.

Brynjolfsson, E. and Hitt, L. M. (2000). Beyond computation: Information technology, organizational transformation and business performance. *Journal of Economic Perspectives, 14,* 23-48.

Chua, S. (1999). Economic growth, liberalization, and the environment: A review of the economic evidence. *ANNU REV ENERG ENV, 24,* 391-430.

Colecchia, A. and Schreyer, P. (2002). ICT investment and economic growth in the 1990s: Is the United States a unique case? A comparative study of nine OECD countries. *Review of Economic Dynamics, 5,* 408-442.

Cooke, P., Uranga, M. G., and Etxebarria, G. (1997). Regional innovation systems: Institutional and organisational dimensions. *Research Policy, 26,* 475-491.

Cooke, P. and Morgan, K. (1998). *The associational economy firms, regions, and innovation*. Oxford England: Oxford University Press.

Daveri, F. (2002). The New Economy in Europe, 1992-2001. *Oxford Review of Economic Policy, 18,* 345-362.

Dewan, S. and Kraemer, K. L. (2000). Information technology and productivity: Evidence from country-level data. *MANAGE SCI, 46,* 548-562.

Forestier, E., Grace, J., and Kenny, C. (2002). Can information and communication technologies be pro-poor? *Telecommunications Policy, 26,* 623-646.

Furman, J. L., Porter, M. E., and Stern, S. (2002). The determinants of national innovative capacity. *Research Policy, 31,* 899-933.

Hanna, N. (1994). Exploiting information technology for development: case study of India. World Bank. World Bank Discussion Paper.

Hassink, R. (2002). Regional innovation support systems: Recent trends in Germany and East Asia. *EUR PLAN STUD, 10,* 153-164.

Hempell, T. (2005). What's spurious, what's real? Measuring the productivity impacts of ICT at the firm-level. *Empirical Economics, 30,* 427-464.

Henry, N. and Pinch, S. (2000). Spatialising knowledge: placing the knowledge community of Motor Sport Valley. *Geoforum, 31,* 191-208.

Hoffman, K. (1985). Microelectronics, international competition and development strategies: The unavoidable issues -- Editor's introduction. *World Development, 13,* 263-272.

Howells, J. (1999). Regional Systems of Innovation? In *Innovation policy in a global economy* (Cambridge University Press.

Hu, M. C. and Mathews, J. A. (2005). National innovative capacity in East Asia. *Research Policy, 34,* 1322-1349.

Hudson, H. (1995). *Economic and Social Benefits of Rural Telecommunications* World Bank.

Jalava, J. and Pohjola, M. (2002). Economic growth in the New Economy: evidence from advanced economies. *Information Economics and Policy, 14,* 189-210.

Jorgenson, D. W. (2003). Information Technology and the G7 Economies. *World Economics, 4,* 139-170.

Jorgenson, D. W. (2001). Information technology and the US economy. *American Economic Review, 91,* 1-32.

Jorgenson, D. W., Ho, M. S., and Stiroh, K. J. (2003a). Lessons from the US growth resurgence. *Journal of Policy Modeling, 25,* 453-470.

Jorgenson, D. W., Ho, M. S., and Stiroh, K. J. (2003b). Lessons for Europe from the U.S. Growth Resurgence. *CESifo Economic Studies, 49,* 27-47.

Jorgenson, D. W. and Stiroh, K. J. (1999). Information technology and growth. *American Economic Review, 89,* 109-115.

Jorgenson, D. W. and Vu, K. (2005). Information technology and the world economy. *Scandinavian Journal of Economics, 107,* 631-650.

Kiangi, G. E. and Mshigeni, K. E. (2002). Information and Communication Technology (ICT) and economic development: A framework for change in developing countries. *Discovery and Innovation, 14,* 38-45.

Kraemer, K. L. and Dedrick, J. (1994). Payoffs from Investment in Information Technology - Lessons from the Asia-Pacific Region. *World Development, 22,* 1921-1931.

Leydesdorff, L. and Fritsch, M. (2006). Measuring the knowledge base of regional innovation systems in Germany in terms of a Triple Helix dynamics. *Research Policy, In Press, Corrected Proof.*

Lundvall, B. and Johnson, B. (1994). The Learning Economy. *Industry andamp; Innovation, 1,* 23-42.

Lundvall, B. A. (1985). *Product Innovation and User-Producer Interaction.* Aalborg: Aalborg University Press.

Lundvall, B. A. (2000). From the Economics of Knowledge to the Learning Economy. In *Knowledge management in the learning economy* (Paris: OECD.

Malecki, E. J. (2003). Digital development in rural areas: potentials and pitfalls. *Journal of Rural Studies, 19,* 201-214.

Mansell, R. (1999). Information and communication technologies for development: assessing the potential and the risks. *Telecommunications Policy, 23,* 35-50.

Maung, K. S. and Harindranath, G. (2004). Conceptualizing the ICT Artifact: Toward Understanding the Role of ICT in National Development. *The Information Society, 20,* 15-24.

O'Mahony, M. and van Ark, B. (2003). *EU Productivity and Competitiveness: An Industry Perspective Can Europe Resume the Catching-up Process?* Office for Official Publications of the European Communities.

OECD (1989). *Information technology and new growth opportunities.* Paris: OECD.

OECD (2003a). *ICT and Economic Growth*.

OECD (2003b). *The Economic Impact of ICT*.

OECD (2005). *Guide to Measuring the Information Economy*.

Oliner, S. and Sichel, D. (2000). The Resurgence of Growth in the late 1990's: Information

Technology the Story? *Journal of Economic Perspectives, 14*, 3-22.

Oulton, N. (2002). ICT and productivity growth in the United Kingdom. *Oxford Review of Economic Policy, 18*, 363-379.

Pilat, D. and Lee, F. C. (2001). Productivity Growth in ICT-producing and ICT-using Industries: A Source of Growth Differentials in the OECD? OECD Directorate for Science, Technology and Industry.

Pohjola, M. (2002). The New Economy in growth and development. *Oxford Review of Economic Policy, 18*, 380-396.

Radosevic, S. (2002). Regional Innovation Systems in Central and Eastern Europe: Determinants, Organizers and Alignments. *The Journal of Technology Transfer, 27*, 87-96.

Roller, L.H and Waverman, L. (2001), Telecommunications Infrastructure and Economic Development: A Simultaneous Approach. *The American Economic Review, Vol. 91, No. 4,* 909-923

Sachs, J. and McArthur, J. (2005). The Millennium Project: a plan for meeting the Millennium Development Goals. *The Lancet, 365,* 347-353.

Sachs, J., United Nations Development Programme, UN, M. P., UN, M. P., and Report to the UN Secretary-General (2005). *Investing in development a practical plan to achieve the Millenium Development Goals*. London: Earthscan.

Schreyer, P. (2000). *The Contribution of Information and Communication Technology to Output Growth: A Study of the G7 Countries* OECD Directorate for Science, Technology and Industry.

Stern, S., Porter, M. E., and Furman, J. L. (2000). The Determinants of National Innovative Capacity. *National Bureau of Economic Research Working Paper Series, 7876*.

Stiroh, K. J. (2002). Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say? *The American Economic Review, 92*, 1559-1576.

Storper, M. (1995). The Resurgence of Regional Economies, Ten Years Later: The Region as a Nexus of Untraded Interdependencies. *European Urban and Regional Studies, 2*, 191-221.

Timmer, M. P. and van Ark, B. (2005). Does information and communication technology drive EU-US productivity growth differentials? *Oxford Economic Papers-New Series, 57*, 693-716.

UNCTAD, Information Economy Report, 2006

United Nations ICT Task Force (2003). *The Role of ICT in Enhancing the Achievement of the Millennium Development Goals* United Nations ICT Task Force.

van Ark, B., Inklaar, R., and McGuckin, R. H. (2002). "Changing gear" : productivity, ICT and services: Europe and the United States. [GD-60]. Groningen Growth and Development Centre, University of Groningen. GGDC Research Memorandum.

van Ark, B., Inklaar, R., and McGuckin, R. H. (2003). ICT and Productivity in Europe and the United States Where Do the Differences Come From? *CESifo Economic Studies, 49,* 295-318.

Zhou, Y. and Xin, T. (2003). An innovative region in China: Interaction between multinational corporations and local firms in a high-tech cluster in Beijing. *Economic Geography, 79,* 129-152.