Exploring the Impacts of ICT on Dimensions of Human Development in the Caribbean: A Preliminary Analysis

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ABSTRACT

For a debt-burdened, developing country that is weathering a global recession, investment in areas that provide a significantly positive social and/or economic return is particularly critical. Increased investment in Information and Communications Technology (ICT) is currently being proposed as a means of improving developing economies, which brings the topic of ICT investment to greater significance to local and regional interests. Globally, there has already been significant research on the effect of investments in ICT in developed economies. However, there is still limited analysis regarding the effect on developing economies, such as those within the Caribbean. Furthermore, the existing research focuses on measures such as Gross Domestic Product (GDP) and leaves room for the evaluation of the effect on other measures. The purpose of this study is to use regression analysis to determine the economic effect, if any, within the Caribbean region of prior investment in ICT and discuss any characteristics of these economies that may dampen or amplify its impact.

Keywords:

Information and Communication Technology, Gross Domestic Product, Human Development, Regression Analysis.

INTRODUCTION

Multiple studies have explored the effect of investment in Information and Communication Technology (ICT) on developed economies, including those of Kraemer and Dedrick (2001) and Daveri (2000). There is widespread agreement that ICT has contributed significantly to growth within these economies. Indeed, Colecchia and Schreyer (2002) calculate that ICT contributed as much as 90% of the economic growth within a selection of OECD countries in the 1990s.

However, despite the evidence of the impact of ICT on developed economies, there is concern in some quarters that this may not translate to developing economies (Economist, 2004). Furthermore, there is the suggestion that investment in ICT does not have as big an effect in developing economies as direct expenditure in health care and education (Suden and Wicander, 2002). It has also been argued that ICT investment would be more effective when paired with complementary investment in health care and education (Ngwenyama et al, 2006).

Compared to the substantial body of work referencing developed countries, there is still limited research on the impact to date of ICT on developing economies, including within the Caribbean region. Inter alia, Piatkowski (2003) and Samoilenko and Osei-Bryson (2011) have examined the effect of ICT on certain economies within Europe and Asia that are transitioning from a centralized planning to a free market economy. Kuppusamy and Shanmugam (2007) quantified the effect of Malaysia's ICT policy on the Gross Domestic Product. There is still room for research in the Caribbean region, which this paper attempts to begin to address.

In this paper, we explore the following questions:

1. Does ICT use have a positive effect on economic growth in the ten Caribbean countries being considered?
2. How does ICT use interact with economic and demographic variables to affect economic growth?

These questions are of import to:

1. Policymakers, who must decide how to invest scarce resources in sectors that will provide the best return for their people. An understanding of the effect of ICT investments to date can provide guidance on whether past investments have yielded measurable results and whether these investments could be further leveraged by other considerations. This information can inform decisions on how to set policy going forward.
2. Taxpayers, who monitor whether their tax dollars are being well spent. Informing the public about the benefits, if any, of the government's investment in technology may, among other things, promote its effective use.
3. Academics, who wish to expand their study to an ever increasing group of economies. It is hoped that an understanding of the subject matter will grow as research expands to include additional areas.

Bankole et al (2011) have considered the effect of ICT investments on three standards of human development (standard of living, education and health) by analysing data for 51 countries across Europe, Asia, Oceania and the Americas from 1994 to 2003. The 51 countries were split into three groups (high, medium and low income) based on their GDP per capita. It was observed that investment in telecoms had a statistically significant positive effect on standard of living (as measured by GDP per capita), education (as measured by literacy rate) and health (as measured by life expectancy) for the 17 low income countries being considered.

Using stepwise ordinary least squares regression, Ngwenyama (2006) showed that, for a sample of five West African countries, investment in a combination of health care, education and ICT had a positive effect on the Human Development Index between 1993-1999. Morawczynski and Ngwenyama (2007) went on to use Multivariate Adaptive Regression Splines analysis to show that the effect of ICT investment was highly dependent on the corresponding investments in health care and education. Furthermore, in some cases, investment in ICT beyond a critical threshold did not yield significantly positive results.

While Ngwenyama and Morawczynski (2007) and Bollou and Ngwenyama (2008) have researched these issues in the context of a subset of West African countries, Samoilenko and Osei-Bryson (2010) have considered the question of the contribution of ICT to human development within selected transition economies of Eastern Europe.

This paper will focus on a selection of nations in the Caribbean region, namely: The Bahamas, Barbados, Belize, Cuba, Dominican Republic, Guyana, Haiti, Jamaica, Suriname, Trinidad and Tobago. The study aims to contribute to the field by exploring how recent findings can be expanded and adapted to include the Caribbean dataset. Furthermore, the results of the analysis will highlight how the interaction of investments in ICT, health and education can impact human development. Our research approach can be considered to be an exploratory cross country empirical study.

The rest of the paper is organized as follows: Section 2 discusses the motivation for the framework of this research. Section 3 describes the methodology, while Section 4 presents the data and the results of our analysis.

2.0 MOTIVATING FRAMEWORK

The Economist Intelligence Unit's 2004 report "*Reaping the Benefits of ICT: Europe's productivity challenge*" investigated ICT's impact on economic growth between 1995 and 2002

for a cross section of 60 European countries. The authors began their work by highlighting the significance of ICT on the US economy and raising the question of whether its impact on Europe would be comparable.

The dependent variable, economic growth, was calculated as the average annual growth in real GDP per capita from 1995 to 2002. In the base model, the explanatory variables were selected to coincide with those described in a typical neo-classical economic model namely initial income level (natural logarithm of GDP per capita), demographic variables (average annual rate of growth of total population, average annual rate of growth of population aged 15-64) and educational capital (mean years of schooling of the adult population).

It was noted that the authors reported significant data shortcomings related to the available mean years of schooling dataset, including missing country values. The problems were addressed by estimating this variable using a regression on primary, secondary and tertiary enrolment ratios, which were available for the countries being considered.

Once the base model variables (initial income level, demographic variables, educational capital) were explored, the model was expanded to include other variables that had been proven to be statistically significant in past empirical studies including a dummy variable that was assigned a value of 1 if the country was an oil producer and 0 otherwise, a dummy variable that was assigned a value of 1 if the country was judged to have an open economy and 0 otherwise and exchange rate volatility as measured by the standard deviation of the annual changes in the exchange rate over the period.

Finally, variables quantifying the level of the country's ICT development were included. Here, ICT is measured as of the start of the period to guard against the effect of possible reverse causality between ICT use and economic growth. The ICT measure itself is a composite index of four indexes. The first index was derived from converting the fixed telephone lines penetration (per 100 population) into an index on a 1 - 10 scale, where 1 corresponded to the minimum value and 10 to the maximum value from the country sample. The same exercise was repeated for

Mobile phones penetration (per 100 population), Personal computers (per 100 population) and Internet users (per 100 population). The resulting four indexes were averaged to arrive at a single ICT index.

Before running the regression, the 60 countries were split into two groups – developed and developing economies - by virtue of the level of their GDP per capita. This distinction would allow researchers to see if the effect of ICT varied for both groups.

The study found that ICT use had no statistically significant impact on the economic growth of the group of developing countries. On the other hand, both the ICT variable and the square of the ICT variable had a statistically significant impact on economic growth for the sample of developed countries. Based on the nature of this relationship, the authors concluded that ICT would have a positive effect only after a threshold had been reached. Furthermore, ICT use will have an effect after a minimum threshold of ICT use had been reached and after an adjustment period had passed.

This structure was considered as a starting point for the model presented in this study. The conceptual framework resembles a translog production framework and has the following form

$$\ln(\text{change in GDP per capita}) = \beta_0+\beta_1*\text{Pop\_Growth}_{15\text{-}64} +\beta_2*\text{Pop\_Growth} + \beta_3*\text{School}_{t\text{-}5} +\beta_4*\text{Internet} + \beta_5*\text{Phone} + \beta_6*\text{Internet}*\text{School}_{t\text{-}5} +\beta_7*\text{Phone}*\text{School}_{t\text{-}5} +\beta_8*\text{Phone}*\text{Phone}$$

where

β_1, $\beta_2 \ldots \beta_n$ are regression coefficients

The model presented in Sections 3 and 4 attempts to show some interaction between ICT measured but is not intended to suggest that the components listed are the only or are the most significant contributors to economic growth.

3.0 METHODOLOGICAL APPROACH

3.1 Data Collection

In our study, we analyze data on ten Caribbean countries using information taken from the World Bank's WDI database as of April 2013 (web.worldbank.org/WEBSITE/ EXTERNAL/ DATASTATISTICS) and the United Nation's Human Development Report from 1995 through 2011. The period under consideration runs from 1995 – 2010 inclusive and was selected as it includes the period that mobile and internet usage gained popularity across the Caribbean region. It should be noted that data from these sources have been used in several published studies that explored the impact of ICT on dimensions of human development.

The independent variables being considered include demographic variables (rate of growth of the total population and the rate of growth of the proportion of the population aged 15-64), measures of the education capital of the underlying population (mean years spent in school) and ICT penetration indicators (landline, mobile phone and internet subscribers as a percentage of population). We look at specific demographic and ICT factors at single point in time and investigate their effect on the dependent variable, GDP growth over a 5 year period. The variables are chosen to represent population, education and ICT use, which we hypothesise have an effect on economic growth. These variables are in line with those used in similar work from the Economist Intelligence Unit.

Table 1. Variables

Name	**Description**
Pop 15-64 Growth	Annual Rate of Growth of the Proportion of the Population Aged 15-64 years
Pop Growth	Annual Rate of Growth of the Total Population
$School_{t-5}$	Average Number of Years of Schooling

Internet	Internet subscribers as a percentage of population
Land	Landline Phone subscribers as a percentage of population
Mobile	Mobile Phone subscribers as a percentage of population
Phone	Average of Landline Phone and Mobile Phone subscribers as a percentage of population

3.1.1 Demographic Variables

The population of the ten countries ranged from just over 200,000 (Bahamas, Barbados, Belize) to close to 11,000,000 (Cuba). As shown in Table 2, all ten countries recorded increases in the both the total population and the working age population. Implied here is the simplifying assumption that the 15-64 age group is the portion of the population that supports the youth (0-14) and elderly (over 65). Therefore, a high proportion of persons aged 15-64 implies that a large portion of the population is available to produce goods and services and to support the so called dependent age groups.

Table 2. Population Data: 2010 vs 1995

Country	Population ('000)		Population Aged 15-64 (%)	
	1995	**2010**	**1995**	**2010**
Bahamas	280	343	64	71
Barbados	263	273	66	71
Belize	217	345	52	61
Cuba	10,901	11,258	68	70
Dominican Republic	7,916	9,927	59	63
Guyana	728	754	60	62
Haiti	7,878	9,993	54	60
Jamaica	2,480	2,702	59	63
Suriname	435	525	63	65
Trinidad and Tobago	1,261	1,341	63	72

3.1.2 Education

The variables reflecting education level (education index, percentage of population with a tertiary education, average number of years in school) were incomplete. Furthermore, data tables that could have been used to build a regression model predicting one of these variables were also incomplete. However, attempts were made to address these significant data issues.

First, we made the simplifying assumption that data in the missing years followed the same linear trend as the available data. In other words, for the entire period under examination, the average number of years in school was assumed to change smoothly, in line with the behavior observed from 2005 to 2010.

Another data shortcoming was that the average number of years in school in the Bahamas was unavailable till 2010. To approximate the figures for earlier years, the data points for the Caribbean region from 1995-2010 were multiplied by a factor reflecting the ratio of the average number of years in school in the Bahamas versus the Caribbean region in 2010. Therefore, the Bahamas education statistics were assumed to behave in the same pattern as that of the Caribbean when considered in its entirety. The method used to fill in the missing education data has flaws. However, it is a simple and not unreasonable means of reflecting to some extent the behavior of the variable given the limited data available.

Table 3. Education Data: 2010 vs 1995

Country	Estimated Mean Years of Schooling	
	1995	**2010**
Bahamas	7.4	8.5
Barbados	8.2	9.3
Belize	8.5	8
Cuba	9.3	10.2
Dominican Republic	5.5	7.2
Guyana	7.4	8.5
Haiti	3.3	4.9
Jamaica	8.2	9.6
Suriname	7.2	7.2
Trinidad and Tobago	7.8	9.2

3.1.3 ICT Usage

During the period under consideration, there was a sharp rise in mobile phone subscription across the countries being studied. Internet subscription also rose, but typically did not keep up with corresponding mobile phone numbers. Over the same period, landline subscription increased relatively modestly and actually declined in Belize, Haiti and Jamaica. Except for Cuba, mobile subscription surpassed landline and internet subscription in the countries being examined. In five of the ten countries analysed, there was more than one mobile phone subscription per person. (See Table 4)

Table 4. ICT Data: 2010 vs 1995

Country	Per 100 population					
	Landlines		Mobile Subscribers		Internet Subscribers	
	1995	2010	1995	2010	1995	2010
Bahamas	29.9	37.7	1.5	124.9	1.0	43
Barbados	34.2	50.3	1.8	128.0	0.0	70.2
Belize	13.1	9.7	0.7	62.3	0.0	12.7
Cuba	3.2	10.3	0.0	8.9	0.0	15.9
Dominican Republic	7.4	10.2	0.7	89.6	0.0	39.5
Guyana	6.1	19.9	0.2	73.6	0.0	29.9
Haiti	0.8	0.5	0.0	40.0	0.0	8.4
Jamaica	11.8	9.6	1.8	116.1	0.1	26.5
Suriname	12.4	16.2	0.4	169.6	0.1	31.6
Trinidad and Tobago	16.6	21.9	0.5	141.2	0.2	48.5

In line with the work completed by the Economist's Intelligence Unit, each of these three variables is transformed into an index ranging from 1 to 10, where 1 corresponds to the minimum value and 10 to the maximum value of the sample.

3.2 Research Questions of the Study

The questions being considered include:

1. How does ICT status affect a countries GDP growth?
2. How do demographic factors interact with ICT use to affect a country's GDP growth?

These questions are of great significance to policymakers, who rely on information about how the investment in ICT in isolation and in collaboration with other variables would affect economic well-being. This information in turn is expected to guide government investment and policy.

3.3 Results of the Data Analysis

When only our demographic variables are included, it is observed that merely having a large population of working age is not enough to exert a positive effect on the economy. Rather, it is the education level of the underlying population that is of some significance for predicting economic growth.

Table 5.

Regression of Change in GDP per Capita on Demographic and Education Variables				
Adjusted R^2	**Independent Variables**	**Coefficients**	**t value**	**p value**
0.136	Pop15-64 Growth	1.16	1.65	0.10
	Pop Growth	-1.61	-1.84	0.07
	$School_{t-5}$	0.03	3.28	0.00

Adding our ICT variables improves the fit of the model so that the R^2 statistic increases substantially from 0.136 to 0.366. All the included variables are now statistically significant.

Table 6.

Regression of Change in GDP per Capita on Demographic, Education and ICT Use Variables				
Adjusted R^2	**Independent Variables**	**Coefficients**	**t value**	**p value**
0.366	Pop15-64 Growth	1.53	2.54	0.01
	Pop Growth	-2.32	-3.04	0.00

	$School_{t-5}$	0.02	2.63	0.01
	Internet	0.04	3.42	0.00
	Phone	-0.08	-6.30	0.00

As a next step, we consider the case when a combination of two independent variables already considered has an effect on GDP per capita growth. Allowing such an interaction among the demographic and ICT variables increased the fit of the model to 58.7%. The interaction between ICT and education level is statistically significant, suggesting that ICT use in collaboration with the education of the population will have a greater effect on the economy than ICT use or education in isolation.

Table 7.

Regression of Change in GDP per Capita on Demographic Variables				
Adjusted R^2	**Independent Variables**	**Coefficients**	**t value**	**p value**
0.587	Pop15-64 Growth	3.85	2.63	0.01
	Pop Growth	-1.56	-0.80	0.43
	$School_{t-5}$	0.13	7.18	0.00
	Internet	-0.23	-1.99	0.05
	Phone	0.78	6.50	0.00
	Internet * $School_{t-5}$	0.03	2.39	0.00
	Phone * $School_{t-5}$	-0.09	-6.90	0.00
	Internet * Pop15-64 Growth	0.60	0.78	0.44
	Phone * Pop15-64 Growth	-0.81	-1.13	0.26
	Internet * Pop Growth	-0.36	-0.37	0.72
	Phone * Pop Growth	-0.88	-0.80	0.43

The nature of the relationship was explored further by examining the effect of letting the ICT variables interact with themselves. R^2 inched up to 59.7%. However, the coefficients of the new variables are not statistically different from 0.

Table 8.

Regression of Change in GDP per Capita on Demographic Variables				
Adjusted R^2	**Independent Variables**	**Coefficients**	**t value**	**p value**
0.597	Pop15-64 Growth	3.92	2.30	0.02

	Pop Growth	-1.27	-0.62	0.53
	$School_{t-5}$	0.13	5.39	0.00
	Internet	-0.33	-2.66	0.01
	Phone	0.87	6.37	0.00
	Internet * $School_{t-5}$	0.05	3.17	0.00
	Phone * $School_{t-5}$	-0.10	-6.12	0.00
	Internet * Pop15-64 Growth	1.00	1.28	0.20
	Phone * Pop15-64 Growth	-0.97	-1.23	0.22
	Internet * Pop Growth	-0.98	-0.96	0.34
	Phone * Pop Growth	-0.67	-0.67	0.50
	Internet* Internet	-0.01	-1.96	0.05
	Phone*Phone	0.00	0.22	0.83

A simpler version of the model is presented below. All the independent variables included are statistically significant. The tradeoff here is that R^2 declines somewhat but we have a simpler model than the one presented in Table 7.

Table 9.

Regression of Change in GDP per Capita on Demographic Variables				
Adjusted R^2	**Independent Variables**	**Coefficients**	**t value**	**p value**
0.489	Pop15-64 Growth	2.22	3.68	0.00
	Pop Growth	-3.25	-4.26	0.00
	$School_{t-5}$	0.04	2.10	0.04
	Internet	-0.24	-2.37	0.02
	Phone	0.36	3.47	0.00
	Internet * $School_{t-5}$	0.04	3.02	0.00
	Phone * $School_{t-5}$	-0.04	-3.25	0.00
	Phone * Phone	-0.02	-3.22	0.00

Change in GDP per Capita = $2.22*Pop\_Growth_{15-64} - 3.25*$ Pop_Growth + $0.04*School_{t-5} - 0.24*Internet + 0.36*Phone + 0.04*Internet*School_{t-5}$ - $0.04*Phone*School_{t-5}$ - $0.02*Phone*Phone$

In order to determine the conditions under which the Internet has a positive impact on GDP growth, we determine when the partial derivative of GDP with respect to the ICT index is positive. The first derivative in this case is the result of differentiating all terms that include the variable for the Internet index. In other words, the partial derivative is $0.04*School_{t-5}$ - 0.24. As

shown below, this is positive when the Mean Years of School (i.e. $School_{t-5}$) at the start of the 5 year interval is more than 6 years.

$$0.04 * School_{t-5} - 0.24 > 0$$

$$0.04 * School_{t-5} > 0.24$$

$$School_{t-5} > 6$$

Similarly, the Phone ICT index has a positive impact on GDP growth whenever the partial derivative of GDP with respect to the Phone index is positive. The derivative in this case is the result of differentiating all terms that include the variable for the Phone index. This happens whenever

$$-0.36 – 0.04 * School_{t-5} – 0.04*Phone > 0$$

$$0.04 * School_{t-5} + 0.04*Phone > 0.36$$

$$School_{t-5} + Phone > 9$$

In other words, for the data presented, increasing the Phone Index had a positive effect on GDP growth till a critical point, after which this pattern reversed. Furthermore, the less educated the population, the greater the Phone Index could increase before this critical point would be reached.

4. CONCLUSION

In this paper we have explored the impact of investments in ICT on economic growth on a set of small island developing states in the Caribbean. We adopted a framework that involved the use of lagged variables and interactions between variables. For example, we assumed that the significant impact of investments in education in a given year would not occur in that year but in later years. Results from our analysis suggest that that ICT use has statistically significant effect on economic growth in the ten Caribbean countries being considered. Furthermore, the nature of this effect depends on the interactions between ICT use and education level. The main conclusion is that investment in education should be explored hand in hand with investment in ICT. Although its effect on growth is statistically significant, ICT investment is not a panacea for economic ails. Over time, perhaps with a shift from its use as a tool for education and industry to one for entertainment, its effect can actually become economically negative.

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