How does Information and Communication Technology (ICT) affect GDP per Capita and Trade volume in Land Locked Developing countries in Asia, Africa, and South America?

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Abstract

This paper aims to quantify the effect of Information and Communication Technology (ICT) on Trade volume and GDP per Capita. Due to lack direct access to the warm waters, high transport and transit costs land locked developing countries are at a significant economic disadvantage compared to the rest of the world. In quantifying the effect of ICT on economic growth and trade volume, I employ a two-way fixed effect model to quantify the effect of ICT growth on trade volume and GDP per Capita. I use secondary data from the World Bank Database and International Telecommunication Union.

This paper aims to quantify the effect of ICT development in terms different ICT indicators. Indicators required for enabling infrastructure or the adoption of technology among the population as identified by International Telecommunication Union (ITU) are Fixed-telephone subscriptions, Mobile-cellular subscriptions, Percentage of Individuals using the Internet, Fixed-broadband subscriptions, Mobile-broadband subscriptions, and international bandwidth. This paper applied annual data across a timespan of 14 years, from 2007 to 2020. When regressed GDP per capita and trade volume against all the independent variables and co-variate I find that any one percent Mobile Cellular subscription increases GDP per capita and trade volume by 0.156% and 0.421% respectively.

Introduction

Although Information and Communication Technology is not recognized as pressing infrastructure, the Istanbul Program of Action (IPoA) 2011-2020, which aims to help least developed countries achieve sustainable development, recognizes ICTs as an infrastructure priority on par with water, electricity, and transport. The program also calls to significantly increase access to telecommunication services and strive to provide 100 percent access to the Internet by 2020. The main purpose of this paper is to examine the effect of growth in Information and Communications technology (ICT) on trade volume and Gross Domestic product per Capita in Landlocked developing countries during the time frame 2007-2020. Indicators required for enabling infrastructure as identified by International Telecommunication Union (ITU) are Fixed-telephone subscriptions, Mobile-cellular subscriptions, Percentage of Individuals using the Internet, Fixed broadband subscriptions, Mobile-broadband subscriptions, and international bandwidth.

Since Covid-19 the pandemic many LLDC countries have brought ICT under greater attention. For instance, the International Computer Driving License (ICDL) Foundation program has enabled Aga Khan Education Service Afghanistan to provide a technology enhanced solution to over 400 students who would otherwise have had to suspend their learning in the face of the lockdown caused by the pandemic.[1] Furthermore, Bhutan started providing special discounts on mobile data packages for students and revised the mobile data package rates for the public. The Druk Trace app was also created, which is used for community tracing

1 *Aga Khan Education Service, Afghanistan*. Aga Khan Education Services. (n.d.). Retrieved April 25, 2022, from https://www.agakhanschools.org/Afghanistan/Afghanistan/Article/1316

in Bhutan and uses individual mobile numbers for verification purposes for public places, transport, and events.[2] Likewise, Farmers in Nepal are now able to sell their produce online, after receiving market information with the help of information and communication technologies. Nepal telecom has also subsidized mobile cellular data for students and teachers to help disrupted education system. [3]

Due to their geographic remoteness, their lack of direct access to the open sea and the high transport and transit costs they face, Landlocked Developing Countries are at a significant economic disadvantage compared to the rest of the world. There are several ways through which ICT may affect the flows of economic growth and international trade. First if we look at the classic story Adam Smith told about the division of labor, we know the division of labor is limited by the extent of the market but the market itself, expands with production, and this in turn is governed by the division of labor. In the absence of extraneous obstacles, therefore, it serves as an indispensable tool for economic growth. ICT, likewise, increases the extent of the market thus, increasing the returns to specialization, comparative advantage by connecting landlocked developing countries to the rest of the world.

For my paper I will be using Two-way Fixed effects model. This is because a simple pooled model contains lots of omitted variable bias i.e., many factors which cannot be observed determine both ICT indicators and GDP per capita and Trade Volume making

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2 Sonam, J., & Dorji, S. (2020, November 4). *ICT plays a critical role in tackling the COVID-19 pandemic*. BBSCL. Retrieved April 25, 2022, from http://www.bbs.bt/news/?p=138336+ICT+plays+a+critical+role+in+tackling+the+COVID-19+pandemic

3 *E-shikshya-package*. NT. (n.d.). Retrieved April 25, 2022, from https://www.ntc.net.np/notices/e-shikshya-package

errors auto correlated. With two-way fixed effects model, we can control for countries as well as time. Thus, this paper uses two-way fixed effects model to quantify the effect of ICT growth on Trade Volume and GDP per capita while also including covariates. All dependent and independent variables are transformed into logarithmic form to interpret the elasticity of the parameters i.e., the percentage change. For the research the data have been collected from World Bank Data and International Telecommunication Union.

The result indicates positive and statistically significant results but with the magnitude of the impact being different, depending on the type of technology examined. For instance, Mobile Cellular Subscription has the highest coefficient which means that the magnitude of impact on GDP per capita i.e., growth and trade volume is the highest. Whereas Mobile Broadband Subscription has negative coefficient. This might be because Landlocked developing countries have a backward advantage over developed nations because they can quickly and less riskily adopt technologies, methods of production, and management techniques that have been developed in advanced countries. Similarly, the fixed ICT infrastructure require more fixed cost and are difficult to install in terms of geography as physical infrastructure.

Literature Review

Several research projects on the effects of ICT on trade volume and growth has been done in developed nations. After two decades of productivity slowdown, in the mid to late 1990's the U.S. experienced a period of rapid economic expansion. Jorgenson (2001) Jorgenson Gordon (1999) have assessed a positive relationship between ICT and the resurgence of the American economy

during the late 90s. Many research earlier have primarily been focused on developed countries primarily because of the development and assimilation was concentrated in developed nations.

At present, diffusion of Information Communication Technology (ICT) is a significant area of concern for sustainable development and growth of a country. Considering the accelerated growth and assimilation of ICT has pushed researchers to quantify the impact on economic growth. The study by Toader, Firtescu, Roman and Anton (2018) examined the effect of ICT on economic growth in European Union (EU) countries for a period of 18 years (2000–2017). The study indicates a positive and strong effect of using ICT infrastructure on economic growth in the EU member states, but the magnitude of the effect differs depending on the type of technology. Although research reveals a significant and positive correlation between telecommunications' infrastructure and economic growth, the impact differs by region and income level. To see how it varies Shiu and Lam (2008) studied the causal relationship between telecommunication development and economic growth in different regions and at different income levels for the period 1980 to 2006. Their results indicate that there is a bidirectional relationship i.e., economic growth causes greater telecommunications development and vice versa for high income group European countries. However, for countries lower income levels countries have unidirectional relationship, that is, economic growth causes greater telecommunications development but not vice versa. Likewise, Crandall and Singer (2010) examined the economic impact of broadband investments on consumer welfare, job creation and economic output in the US over the period 2003–2009 and found that increasing broadband investments results in increased employment and GDP.

The paper by Liu and Nath (2013) examines the effects of information and communications technology (ICT) on international trade in emerging markets using panel data for 40 emerging market economies (EMEs) for a period from 1995 to 2010. The empirical results suggest that

Internet subscriptions and Internet hosts have significant positive impacts on both export and import shares in EMEs. Similarly, Clarke and Wallsten (2006) found that higher internet penetration promotes trade flows from developing countries to developed countries, but not vice versa. The paper by Lin (2014) estimated the effect of the Internet on promoting international trade by employing the gravity equation with the Internet, finding that a 10 per cent increase in the Internet users increases international trade by 0.2–0.4 per cent. The study by Xing (2018) examines the impact of Internet and e-commerce adoption on bilateral trade flows using a panel of 21 developing- and least-developed countries and 30 OECD countries. The paper emphasizes on East African Community (EAC) commitment towards being export-led economy across the African continent and thus quantifies the role of ICT and e-commerce on EAC's export performance. The empirical results indicate that better access to the modern ICT and adoption of e-commerce applications stimulate bilateral trade flows at various levels. The study finds that highspeed internet and secured servers can serve as a crucial milestone for unlocking the e-trade potentials for developing- and least-developed counties

The Data

The data for model was taken from World Bank Data group and International Telecommunication Union and were converted to their logarithms which allowed us to present the elasticity. The research looks at the period of 2007-2020 for 31 countries Afghanistan, Armenia, Azerbaijan, Bhutan, Bolivia, Botswana, Burkina Faso, Burundi, Central African Republic, Chad, Eswatini, Ethiopia, Kazakhstan, Kyrgyzstan, Lao PDR, Lesotho, Malawi, Mali, Mongolia, Nepal, Niger, Paraguay, Rwanda, South Sudan, Tajikistan, Turkmenistan, Uganda, Uzbekistan, Zambia,

Zimbabwe. In total, we are working with 420 observations in one panel which will enforce statistical validity of our results and allow us to give policy implications.

Economic Theory

The production function developed by Charles Cobb and Paul Douglas can assist quantifying the effect on ICTs on economic growth.

$$y = AK^{\alpha}L^{1-\alpha}$$

$$\log(y) = \log(A) + \alpha \log(K) + (1 - \alpha) \log(L)$$

Here y represents aggregate output of the country, K the capital input, and L the labor input. The A term represents the state of technology as well as the skill and education level of the workforce. Thus, ICT comes under the term A along with other variables. There still exists lack of labor and capital data for Landlocked developing countries and therefore we cannot isolate A. The two-way fixed effects model allows us to use the empirical approach to help control for time variant differences across counties i.e., the amount of land L and capital K.

There are several ways through which ICT may affect the flows of international trade. First is the classic story Adam Smith told about the division of labor. The division of labor is limited by the extent of the market but the market itself, expands with production, and this in turn is governed by the division of labor. ICT increases the extent of the market thus, increasing the returns to specialization, comparative advantage by connecting landlocked developing countries to the rest of the world.

Second, the use of ICT reduces the entry cost into a market. Freund and Weinhold (2004) include the costs of finding out information about the market, advertising, and establishing a

distribution network as the fixed cost. The paper found that Internet reduces market-specific fixed costs of trade particularly internet-related reduction in fixed costs which enhances export growth. They found through the gravitation model that the Internet does not directly affect the relationship between distance and trade; however, to the extent that competition is enhanced because of its development, the Internet will increase the overall effect of distance on trade. The use of ICT can also reduce delays such as the delay in acquiring and transmitting relevant information and makes planning more efficient and accurate. ICT also facilitates global disaggregation of the production process for information-intensive services and thereby increases trade in those services.

The model uses Trade Volume (Import plus Export) and GDP per capita as dependent variable. This paper aims to quantify the effect of ICT development in terms different ICT indicators. Indicators required for enabling infrastructure or the adoption of technology among the population as identified by International Telecommunication Union (ITU) are Fixed telephone subscriptions, Mobile-cellular subscriptions, Percentage of Individuals using the Internet, Fixed-broadband subscriptions, Mobile-broadband subscriptions, and Percent of Urban Population and average Elevation is used as independent variables to avoid endogeneity as they influence both GDP per capita and Trade volume as well as ICT indicators.

This paper applied annual data across a timespan of 14 years, from 2007 to 2020, in LLDC All the data are secondary data which are retrieved from the World Bank Database and International Telecommunication Union. All dependent and independent variables are transformed into logarithmic form to interpret the elasticity of the parameters i.e., the percentage change which allowed us to present the relationships between variables in an additive equation.

Variables

For this model two-way fixed effects model. We use all the indicators identified by ITU as independent variables i.e., Percentage of People Using Internet in percentage of total population, Fixed Broadband subscriptions Fixed-telephone subscriptions, Mobile Broadband subscriptions, Mobile-cellular subscriptions in terms of number of subscribers and International Bandwidth in terms of Megabits and covariates Urban Population in terms of percentage of people living in urban area and average elevation in feet.

Table 1: Variables and Measurements

	Variables	**Measurement**
Dependent	Trade Volume	Export+Import
	GDP per Capita	Gross Domestic Product per capita
	Export Service	Amount in current $ of export in services
	Export Goods	Amount in current $ of export in Goods
	Trade Service	Amount in current $ of tradein services
	Trade Goods	Amount in current $ of Trade in goods
Independent	Percentage of People Using Internet	Percentage of population using Internet
	Fixed Broadband subscriptions	Number of people using fixed broadband
	Fixed-telephone subscriptions	Number of people using Fixed Telephone
	Mobile Broadband subscriptions	Number of people using Mobile Broadband
	Mobile-cellular subscriptions	Number of people using mobile
	International Bandwidth	Mbits

	Elevation	Average Elevation in Feet
	Urban Population	Percentage of population living in urban area

I predict Percentage of People Using Internet, Mobile-broadband subscriptions, Mobile-cellular subscriptions, Urban Population to have positive coefficient, I predict Fixed ICT infrastructure subscriptions to have low or even negative coefficient. This is because Mobile subscriptions might have served as a supplement/substitute for fixed subscriptions.

Empirical Model

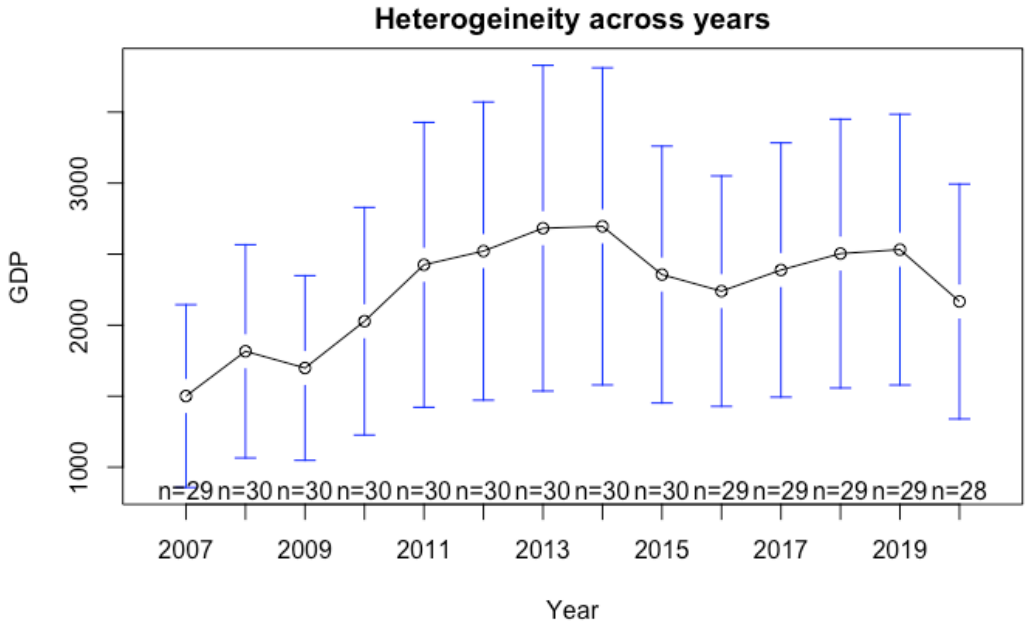
Beginning with the simple pooled regression:

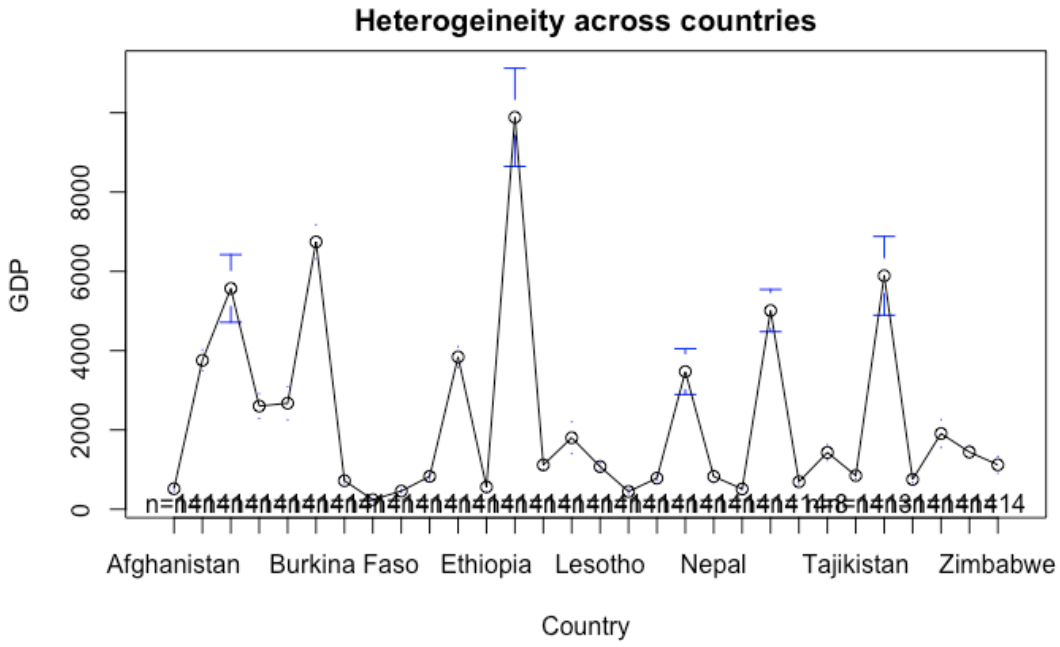
$$GDP=\beta_0+{}_I\beta_1\, log(InternationalBandwidth) + \beta_2\, log(MobileCellular) + \beta_3\, log(FixedBroadband) + \beta_4\, log(FixedTelephone)+u$$

$$TradeVolume=\beta_0+{}_I\beta_1\, log(InternationalBandwidth) + \beta_2\, log(MobileCellular) + \beta_3\, log(FixedBroadband) + \beta_4\, log(FixedTelephone)+u$$

A simple pooled model as such however contains lots of omitted variable bias. Many factors which cannot be observed determine both ICT indicators and GDP per capita and Trade Volume making errors auto correlated. With two-way fixed effects model, we can control for countries as well as time.

This paper uses two-way fixed effects model to quantify the effect of ICT growth on Trade Volume and GDP per capita. TWFE allows us to quantify fixed effect for both group and time and reduces bias from variables that we cannot measure





Regression: Effect of ICT growth on Economic Growth and Trade Volume using

Two-way fixed effects model

$$\log(GDPCapita) = \beta_1 \log(InternationalBandwidth) + \beta_2 \log(MobileCellular) + \beta_3 \log(FixedBroadband) + \beta_4 \log(FixedTelephone) + \beta_5 UrbanPopulation + \beta_6 PercentInternet + \beta_7 log(Elevation) + \beta_8 log(MobileBroadband) + \epsilon$$

$$log(TradeVolume) = \beta_1 log(InternationalBandwidth) + \beta_2 log(MobileCellular) + \beta_3 log(FixedBroadband) + \beta_4 log(FixedTelephone) + \beta_5 UrbanPopulation + \beta_6 PercentInternet + \beta_7 log(Elevation) + \beta_8 log(MobileBroadband) + \epsilon$$

Empirical Results and Analysis

The table following presents the results for different ICT indicators and quantifies their effect both on economic growth and trade volume. The coefficient for the ICT variable β1 through β6 was positive save for Fixed Broadband and statistically significant. Thus, the results do not reject the research hypothesis, suggesting a positive and highly significant impact of ICT infrastructure on economic growth, but with the magnitude of the impact being different, depending on the type of technology examined.

We find that all variables have positive coefficient when we regress GDP per Capita against independent variables and covariates and find that all the variables save International Bandwidth

and Fixed-broadband subscription have negative coefficient when we regress Trade volume against all the independent variables and co-variates.

Variables	GDP per Capita TWFE	Trade Volume TWFE	GDP per Capita Pooled	Trade Volume Pooled
Intercept			10.776 *** (0.624)	25.590 *** (4.397)
Log (International Bandwidth)	0.02 (0.012)	-0.037 * (0.016)	0.128 *** (0.028)	- 0.317 (0.198)
Log (Mobile Cellular)	0.156 *** (0.030)	0.421 *** (0.040)	-0.462*** (0.048)	- 0.982** (0.338)
Log (Fixed Broadband)	0.037 ** (0.010)	0.020 (0.014)	0.103** (0.031)	0.804 *** (0.221)
Log (Fixed Telephone)	0.094 *** (0.015)	0.094 ** (0.019)	0.133*** (0.028)	0.489 * (0.196)
Urban Population	0.005 (0.008)	0.017 (0.010)		
Percent Internet	0.002 * (0.001)	0.005 *** (0.001)		
Log (Mobile Broadband)	-0.001 (0.003)	-0.005 (0.004)		
Number of Samples	420	420	420	420
R^2	0.191	0.280	0.372	0.121

***** p < 0.001; ** p < 0.01; * p < 0.05.**

Any one percent increase in Mobile Cellular Subscription increases GDP per capita by 0.156 percent. Any one percent increase in Mobile Broadband subscription decreases GDP per capita by 0.001 percent. Similarly, any one percent increase in Fixed Telephone Subscription increases both GDP per capita and Trade volume by 0.094 percent. The p-value is less than 0.05, so it indicates that we reject the null hypothesis. Any one percent increase in Mobile Cellular Subscription increases Trade Volume by 0.421 percent.

Any one percent increase in International Bandwidth decreases Trade Volume by 0.037 percent. The p-value is less than 0.05, so it indicates that we reject the null hypothesis.

Conclusion

From the empirical evidence analyzed it would be safe to conclude that ICT plays a significant role in the Trade Volume and GDP per Capita. If we wish to fully understand the effect of ICT on trade volume and economic growth, then the impact of ICT in ICT-using sectors is required to be studied with granular data. Likewise, we need to look more in depth into economic growth and look at whether the relationship is bidirectional i.e., economic growth creates ICT development and vice versa. Although this result has made it evident that ICT positively complements trade volume and GDP per Capita, we can further look at what sector ICT affects more with sector specific data as well as if ICT fosters trade from developing countries to developed nations or vice versa.

It is evident that ICTs can serve as an indispensable tool for sustainable economic development when used and by involving stakeholder's participation and by fine-tuning its policies. LLDC can reap the benefits of comparative advantage by increasing the extent of market. As found in the study the magnitude of ICT infrastructure varies by the type of infrastructure. The outcome of this study will be a useful guide to the government of LLDC,

policy makers and the public on how ICT can be used as a tool for economic growth and development. For instance, if they wish to boost GDP per capita in LLDC by improving ICT the results suggest that the most effective way would be through increased focus on Mobile Cellular Subscription.

The use of ICT allows for global division of labor and allows for transfer of skills, and greater efficiency. As seen from the result of the study if the LLDCs wish to boost trade by focusing on ICT they should emphasize on Mobile Cellular subscription rather than Fixed Cellular Subscription. As discussed earlier this is primarily because the installation of fixed infrastructure is costly and geographically less viable. The intersection of being developing s and landlocked creates resource constraints resulting lesser returns from fixed ICT infrastructures. Thus, to enhance Mobile Cellular services, the opportunities exist to:

- Making the Mobile Cellular market healthy and competitive to extend coverage and making prices affordable.
- Coverage obligations can be included into licenses in a way that makes telecommunication provide services in areas that are economically unviable for commercial operators by subsidizing the higher cost of operation.
- Promote a competitive market so that operators will compete for low-use customers through a variety of plans that cater to different incomes and levels of use, rationalize ICT sector taxation and other fees and having community centers with Internet access.
- Maintain strong technological infrastructure to support the growing need if the nation's technological needs.

Changes as such allows landlocked developing countries to reap benefits of greater returns on investments in Mobile Cellular infrastructures.

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