

Impacts of ICT on Environment in Latin America

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Abstract

One of the most obvious challenges facing the environment, the production of different goods and products harmful to the environment and expand energy that leaves a lot of destructive effects. The use of new technologies can play an important role in this regard. One of these new technologies is ICT. The impact of ICT on the environment is one of the issues are complex and multifaceted. ICT can have both positive and negative effects on environmental sustainability. For this purpose, this study aimed to investigate the effects of ICT on the environment by using panel data for 13 countries of Latin America in the period 2003-2012. The results show that fixed telephone lines as an indicator of ICT and significant negative relationship between CO₂ emissions in countries that have been studied. The variable GDP per capita, the degree of openness of the economy and square GDP in the studied countries have a positive impact on CO₂ emissions.

Keywords

ICT, Environment, Phone Lines, CO₂, Panel Data

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1. Introduction

Information and communication technology (ICT) is considered as one of the most important criteria of economic and industrial development of human societies. The technology in recent decades, has created widespread in all areas of social and economic development and has far-reaching effects on the organization, human and economic communities in the micro and macro level. New developments in ICT have revealed a tendency for countries and organizations in the use of modern technology to achieve organizational objectives and value creation more than ever. Today's man, experiencing a society based on information and communication technology, which has its own characteristics (Niebel, 2014, 1-3). Life in the modern world requires full knowledge and skills is the use of this technology and without such a device, and life would be very difficult competition and lead to the loss of many

opportunities in the daily life of individuals and communities. In addition, ICT known as the main factor of economic growth through increased productivity and human development. Obviously, the changes in ICT, in addition, takes effect on productivity, a change in jobs, skills and roles and responsibilities of the work in organizations, institutions and society (Williams, 2011, 356). Today's world accompanied with many changes of the past and is going on at all fields of economic, political, social and cultural. Investigate, identify, anticipate and adapt to this changing environment requires having adequate plans and strategies with a view to the future with creativity and innovation landscape. That it is essential for any organization, firms production, and each country (Hilty et al, 2006, 1620). Despite the differences in nature and examples of environmental problems in developed countries and developing, environmental management and move to maintain and improve it, is an international concern.

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Therefore, each strategies and tools that can help countries in this regard, can be considered as a general solution. The use and application of ICT and its potential as a result of the transfer of activities in cyberspace, is considered one of the most important platforms and solutions in this respect, whether in developed countries or in developing countries. It can be said, that ICT has been one important factor in transforming human life in recent decades and almost impossible to find a part of human life today (directly or indirectly) that has not benefit from the capabilities of this technology (Ospina, Heeks, 2010). While, without doubt, a significant part of the growth and economic development of countries, especially the developed countries over the last decade, there has been in the light of optimal use of the capabilities of this technology and the opportunities it created (Berkhout and Hertin, 2004, 907). Figure 1 shows the overall picture of the scope and impact of ICT in all aspects of human life. As you can see, different sectors such as health, employment, business, security, the environment, regional development, human rights and education, will benefit from the capabilities of this phenomenon, while in many cases this relationship is two-way.

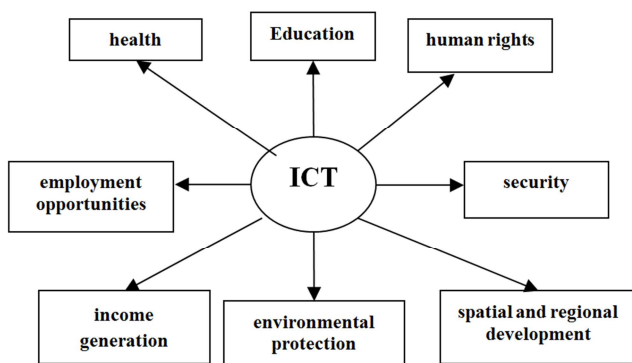


Figure 1. Community development of ICT.

Source: (Wakelin and Shadrach, 2001)

In this framework using the capabilities of ICT in different areas, without a doubt, a significant impact on the environment from the left and leaves and this issue could be considered according the importance of the environment especially in recent decades. So, it seems that to examine the implications of using ICT on the environment in different countries could have new achievements, particularly for policymakers. Therefore, this study seeks to examine the impact of ICT on the environment in 13 selected developing countries in Latin America.

2. Theoretical Foundations and Previous Studies

Information society, for the first time, was introduced in the

1970s by Malchap and Porat. Since then, the concept of information, was considered as an important factor in the development process. At the same time, the emergence of this concept came into being, communication and process technologies in order to receive, transmit and analyze information that became known as ICT (Asgharpour, et al., 2011, 24). The role of these technologies in the development of societies that had spread as far as many specialists benefited from the information and technology related to it in order to explain differences in levels of development among countries and showed that ICT may provide a cheap and efficient way of data collection and evaluation tools that speed up the development process (Trung, 2007, 23). Even in this case, some acknowledged that integration with the world of information, it is impossible for developing countries without access to adequate levels of ICT. Stiglitz (1988), Hamelink (1997) and UNCTAD (2006) are some of these studies. Also the importance of technology and the need to identify the factors and events affecting the use of these instruments has gone as far as which is one of the most important approaches to reduce poverty and promote global development is the adoption of new technologies in less developed regions. However, Zhao (2005) believes that although the globalization process will be able to access these new technologies by many countries, but the intensity and size of acceptance that will determine how the country will benefit from this process. Therefore, in the third millennium, information technology, as a major axis of development in the world, and gains from it, also has been associated with people's lives. It should be noted that, refusal and neglect, it creates, a great confusion in the society, the welfare of the people. Because at present many of the relationships, exchange of information, economic, cultural, academic achievement, access to the latest technologies, it is possible through information technology (Mehrabi et al., 2011, 69).

Thus, ICT is effective comprehensive and inclusive as a phenomenon in the full range of human activities to the private use of political and economic activities. Also, it is intended as a means multi-functional, flexible and has multiple capabilities, that the provides the possibility of appropriate solutions in the form of individual or local applications to meet different needs (UNDP, 2004). In the 1990s, a major transformation as a revolution in ICT, happened in the economy, in fact formed the basis of the new economy and have a significant impact on economic growth in America and some other countries. In the center of the transformation of information was the semiconductor or semiconductors, which led to the rapid decline in the price of semiconductors and cheap semiconductor, let's rapid expansion in the production of computers and

communications equipment and ultimately reduced prices severely in other economic activities. The rapid decline in prices of goods, which had benefited from ICT would be a great investment in the goods and led to a deepening of capital and changes in the organization of production of other goods in the economy and brought the growth of productivity and production. Increase productivity due to the impact of information technology affects three main aspects: First, technological change leads to growth in innovation, second, reduce the price of the means of production of new innovative sectors of the economy the deepening of capital in the economy on a large scale and third, makes the reorganization of production for capital goods in the form of new technologies (Stiroh, 1998, 181).

ICT is growing with astonishing speed. Virtualization many products, digitization of information, the non-physical transfer, reduce the need for extensive space in offices and warehouses and shortening the supply chain, are among the positive results of the development of ICT, on the one hand makes reducing the need for communities to natural substances in the environment and on the other hand, reduces the amount of waste entering the environment. With an overview of the positive effects, the question arises as to whether ICT provides the possibility of obtaining economic growth and environmental protection, and sustainable development? However, one should not forget that the ICT equipment are made, usually environmentally harmful substances and non-absorbable (Pade and Sewry, 2009, 82).

The relationship ICT and environment is a complex and multidimensional topics. This technology can have both a positive and a negative impact on environmental sustainability. ICT provides a powerful tool for communities to protect the environment. This technology provides facilities for human communication which makes reduce the need for communities to natural substances in the environment. As well as, ICT reduce the amount of waste entering the environment. The other hand, production and distribution of ICT equipment itself requires energy and materials and the fact that is ICT equipment, has a short life cycle, this will lead to Increase electronic waste into the environment that are very detrimental effects for the environment (Fallahi et al, 2012, 151). For example, computer systems have been the most harmful chemicals. Also, for the manufacture of these devices is the excessive use of environmental resources. Therefore, addition to positive effects, ICT have negative effects on the environment and the effect of this variable is needed to study (Sojudi et al, 2010, 98).

Ahmed and Ridzuan (2013) in a study have paid the impact of ICT on east asian economic growth using panel data set from 1975 to 2006. The paper found out that labour, capital

and telecommunications investment have positive relationship towards GDP. Thus, the study concludes that ICT has played an important role as engine of growth for sustainable development in ASEAN5 and ASEAN5+3 countries.

Mei Ong and Kun Sek (2013) have examined the interaction effect economic growth and environmental quality in the period 1970-2008 in the three income groups: high, medium and low. The results showed that the variables of trade and inflation has very little effect on the quality of the environment. FDI also has a negative effect on the quality of the environment in low and middle-income countries.

Hepburn and Bowen (2012) investigated in study the relationship between economic growth, environment and climate change in the period 2008-2012. The results suggest that continued economic growth when it is desirable and possible that no harmful effects to the environment.

Kawata (2011) has tried to analyze and explain how the effect of the environment from economic growth by 2 priority natural environment and the opportunity cost of protecting the natural environment. Results indicate that the second factor plays a significant role in improving the quality of the environment.

Constantini and Martini (2010) in a study that examined the effect of internet, fixed and mobile phones per 1000 people to release various contaminants. The results showed that the index of ICT has a positive impact on various contaminants including CO₂.

Giovanni (2010) in a study of factors affecting emissions by industry sector Italy has shown that ICT had no significant effect on emissions of CO₂ and SO₂.

Annette (2009) has investigated the effects of technology on the environment. The results show that the use of recycled and renewable technology to produce its positive effects on the environment, although that increase the amount of mercury entering the factories and producing affect different destructive effects on the environment.

Zhang and Cheng (2009) in a study have paid the relationship between energy consumption, carbon dioxide emissions and economic growth in China. The results indicate that the energy consumption and carbon dioxide emissions have no significant relationship with the country's economic growth.

Barua and Hubacek (2008) have analyzed the relationship between income per capita and water pollution for 16 states in India during the years 1981-2000. The results show that only 12 states significant relationship between income per capita and water pollution can be seen that in 4 states about water pollution and per capita income had been reversed and in 8 other states initially increase per capita income,

increased water pollution 5 thousand rupees will be up to the border, then the descending curve (inverse relationship between income per capita and water pollution) and after reaching a per capita income of 15 thousand rupees direct relationship is established again.

Lopez et al (2008) examined the effect of combining public spending on environmental quality and have shown that increasing public spending in areas such as the environment and communications are reduced CO₂ emissions.

Alam et al (2007) in their study have paid the effect of environmental factors during the years 1971 to 2005 in Pakistan. The main findings of this study suggest that the increase in GDP and energy intensity increased environmental pollution.

Ang (2007) has explored the dynamic causal relation between carbon dioxide emissions, energy consumption and production in France during the years 1960-2000. The results show that economic growth due to long-term energy consumption and environmental pollution, and a one-way causal relationship between the energy consumption is set to increase production in the short term. The findings also show that an increase in energy use, carbon dioxide emissions will increase.

3. Material and Methods

3.1. Data and Statistics

The population of this study are 13 selected developing countries in Latin America, including Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Mexico, Paraguay, Peru, Uruguay and Venezuela. The period has been used 2003-2012. This is the time series data collected from WDI2015 and OECD site statistics.

The model presented in this study, inspired by the Constantini and Martini (2010) as follows:

$$\ln(CO2)_i = \alpha + \beta_1 \ln(GDP_i) + \beta_2 (\ln GDP)_i^2 + \beta_3 OPEN_i + \beta_4 ICT_i + \varepsilon_i \quad (1)$$

Ln CO₂= logarithm of gas emissions per capita Carbon dioxide (CO₂) (in tonnes) of country i

Ln GDP = Logarithm of GDP per capita of country i

Ln OPEN= logarithm of the degree of openness than the sum of exports and imports of goods and services to GDP of country i

Ln ICT= logarithm of ICT index (the number of fixed telephone lines per 100 people) of country i

Also, as can be seen, according to the hypothesis of Environmental Kuznets Curve (EKC) variable square Ln

GDP also included in the model. According to this hypothesis, there is an inverse U-shaped relationship between GDP per capita and indicators of environmental degradation, so that in the early stages of economic growth, the increase in GDP per capita with more environmental destruction, but of a threshold level then, increase economic growth improves the quality of the environment.

3.2. Estimation Method

Panel data is data from a (usually small) number of observations over time on a (usually large) number of cross-sectional units like individuals, households, firms, or governments. In other words panel data analysis is a method of studying a particular subject within multiple sites, periodically observed over a defined time frame. With repeated observations of enough cross-sections, panel analysis permits the researcher to study the dynamics of change with short time series. The combination of time series with cross sections can enhance the quality and quantity of data in ways that would be impossible using only one of these two dimensions (Gujarati, 638). Some more advantages of panel data as given in 'Basic Econometrics' by Gujarati are:

- Since panel data relate to individuals, firms, states, countries, etc over time, there is bound to be heterogeneity in these units. The techniques of panel data estimation can take such heterogeneity explicitly into account by allowing for individual-specific variables.
- By studying the repeated cross section of observations, panel data are better suited to study the dynamics of change.
- Panel data can better detect and measure effects that simply cannot be observed in pure cross-section or pure time series data.
- By making data available for several thousand units, panel data can minimize the bias that might result if we aggregate individuals or firms into broad aggregates.

Panel data analysis endows regression analysis with both a spatial and temporal dimension. The spatial dimension pertains to a set of cross-sectional units of observation. These could be countries, states, counties, firms, commodities, groups of people, or even individuals. The temporal dimension pertains to periodic observations of a set of variables characterizing these cross-sectional units over a particular time span. There are several types of panel data analytic models. There are constant coefficients models, fixed effects models, and random effects models etc. The Constant Coefficients Model has constant coefficients, referring to both intercepts and slopes. In the event that there is neither significant country nor significant temporal effects, we could pool all of the data and run an ordinary least

squares regression model. This model is also called the pooled regression model. The Fixed Effects Model would have constant slopes but intercepts that differ according to the cross-sectional (group) unit—for example, the country. Although there are no significant temporal effects, there are significant differences among countries in this type of model. While the intercept is cross-section (group) specific and in this case differs from country to country, it may or may not differ over time. The Random Effects Model assumes a regression with a random constant term (Greene, 2003). One way to handle the ignorance or error is to assume that the intercept is a random outcome variable. The random outcome is a function of a mean value plus a random error. But this cross-sectional specific error term which indicates the deviation from the constant of the cross-sectional unit must be uncorrelated with the errors of the variables.

4. Results and Discussion

4.1. The Results of F-limer and Hausman

Table 1 shows that the value of F test statistic using fixed effects would be more appropriate. Houseman also test statistic indicates the suitability of the method for estimating the fixed effects model.

Table 1. Results of F-lymr and Houseman test of the estimated model.

Test	F-lymr Test	Houseman Test
Statistics	419/3174	37/6312
Prob	0/0000	0/0000

Sources: research findings

4.2. The Estimation Results

Accordingly, the results of model estimation is introduced to determine the effect of ICT on envirement using a fixed effects panel data are presented in Table 2.

Table 2. Results of estimating the Impacts of ICT on Environment.

Variables	Coefficient	StatisticsT	Prob
LGDP	0/1992	6/3256	0/0000
(LnGDP) ²	0/0063	2/1973	0/0300
LOPEN	0/1716	3/7418	0/0003
LICT	-0/1169	-2/3507	0/0203
R ² = 0/9840	$\bar{R}^2=0/9818$	D-W =1/8046	

Sources: research findings

As the results show that the Ln GDP coefficient is positive. So that a one percent increase in GDP per capita, the rate of growth in emissions of Carbon dioxide (CO₂) increases, 0/19 percent. This suggests the use of dirty technologies and inconsistent with the environmental standards in production in various economic sectors in the countries studied. Also squared coefficient of per capita GDP does not comply with

the EKC hypothesis. Because it would be 2 then analyzed. Lack of proper laws of environmental protection in the countries studied can be considered a factor in the increased pollution. Also because most polluting industries, worn and old developed countries to the developing countries down, so these industries are increasing CO₂ emissions in the environment. So increase in production was associated with an increase in environmental pollution. The coefficient estimates for the degree of economic openness is equal to 0/17. This indicates the existence of a positive relationship between these variables and the growth of CO₂ emissions. As mentioned, increased production, will increase pollution and the degree of openness is achieved from the composition of exports and imports, then a positive effect on emissions can not be far-fetched. The estimated coefficient is negative for ICT. This issue shows, that by increasing the availability of landline infrastructure development in the field of communications can have a significant impact in reducing travel and reduce energy consumption and pollution in the countries studied. Also, as can be seen in the estimated model R² is 0/98 that it shows the explanatory power of the independent variables.

5. Conclusion

Undoubtedly, in recent decades, information and communication technologies (ICT), has made extensive changes in all economic and social areas. The scope of the application and impact of this technology on life to the extent that today one of the most important issues on the world and attracted the attention of many countries in the world. This technology has far-reaching effects on the economy, production, productivity and the environment. The impact of ICT on the environment can be many sizes. So that it can be expected, the use of technology have a positive effect on the environment or vice versa will have a devastating impact on environmental sustainability. The use of ICT can reduce dependence on the environment and on the other hand, the production of ICT equipment such as computers, tools, mobile phones and other environmentally harmful substances can have negative effects on the environment. This study examined the use of ICT for environmental quality in 13 selected developing countries in Latin America in the period 2003-2012 using panel data model. The results showed telephone lines has a significant negative effect on the quality of of the environment in studied countries. The variable GDP per capita and square it has a positive effect on CO₂ emissions is significant. Also, the results showed that the degree of openness had a positive relationship with CO₂ emissions.

References

- [1] Ahmed, E., M., Ridzuan, R. (2013), the Impact of ICT on East Asian Economic Growth: Panel Estimation Approach, *Journal of the Knowledge Economy*, December, Volume 4, Issue 4, 540-555.
- [2] Alam, S., Ambreen, F., Butt, M. (2007), Sustainable Development in Pakistan in context of energy consumption demand and environmental degradation, *Journal of Asian Econometrics*, Vol 18, 825-837.
- [3] Ang, J. B. (2007), CO₂ emission, energy consumption and output in France, *Energy Policy*, Vol 35, 4772-4778.
- [4] Annette Rose, M. (2009), Impacts of Technology on the Environment Resources for Decision Making, *Enviro Tech Department of Technology Ball State University*, April, 1-38.
- [5] Asgharpour, H., Mohammadzadeh, Jalilpour, S. (2011), The effect of development indicators in the adoption and use of information and communication technologies (ICT) in Selected Asian Countries, *Journal of Economics and regional Development*, first Year, Issue 1, the first half, 22-50.
- [6] Barua. A., Hubacek, K. (2008) Water pollution and economic growth: an Environmental Kuznets Curve analysis at the watershed and state level. *International Journal of Ecological Economic and Statistics*, 10(8), 1-25.
- [7] Berkhout, F., Hertin, J. (2004). De-materialising and re-materialising: Digital technologies and the environment. *Futures* 36, 903–920.
- [8] Constantini, V., Martini, C. (2010), A Modified Environmental Kuznets Curve for Sustainable Development Assessment Using Panel Data, *International Journal of Global Environmental*, Vol. 10, 84-122.
- [9] Fallahi, F., Sojudi, S., Mamiepoor, S. (2012) examines the impact of information and communications technology (ICT) on Environmental Quality Iran, *Iranian Energy Economics*, 1, No. 2, Spring, 149-172.
- [10] Giovanni, M. (2010), Sector CO₂ and Sox Emissions Efficiency and Investment: Homogeneous vs Heterogeneous Estimates Using the Italian NAMEA, ISEE 2010 Confrence Advancing Sustainability in Time of Crisis 22-25, August, 2010-Oldenburg and Bremen, Germany.
- [11] Greene, W. H. (2003). *Econometric Analysis*, Prentice Hall.
- [12] Gujarati, D. (2003). *Basic Econometrics*, the McGraw-Hill.
- [13] Hamelink, C. J. (1997), *New Information And Communication Technologies, Social Development And Cultural Change*, UNRISD Discussion Paper 86, Geneva, Unrisd.
- [14] Hepborn, C., Bowen, A. (2012) Prosperity with growth: Economic growth, climate change and environmental limits, *Grantham Research Institute on Climate Change and the Environment Working Paper No. 93*.
- [15] Hilty, L., Arnfalk, P., Erdmann, L., Goodman, J., Lehmann, M., Wager, P. (2006). The relevance of information and communication technologies for environmental sustainability: A prospective simulation study. *Environmental Modeling & Software*, 21(11), 1618–1629.
- [16] Kawata, Y. (2011) Impacts of Economic Growth and Environmental Quality: Does the inverted U-shaped relationship hold? *Journal of Environmental Science and Management* 14(2), 42-50.
- [17] Lopez, R., Galinato, G., Islam, A. (2009), Fiscal Spending and the Environment: Theory and Emprics, Working Papers 2009-22, School of Economic Sciences, Washington State University.
- [18] Mehrabi, J., Ansari J., Mohammed Reza, Baba Ali, A.J. (2011), The effect of ICT on the efficiency of the educational staff (teachers of secondary school education in the city of Khorramabad a), *Journal of Management*, 8, Supplement, spring, 78-68.
- [19] Mei Ong, S., Kun Sek, S. (2013) Interactions between Economic Growth and Environmental Quality: Panel and Non-Panel Analyses, *Applied Mathematical Sciences*, Vol. 7, No. 14, 687–700.
- [20] Niebel, T. (2014), ICT and Economic Growth - Comparing Developing, Emerging and Developed Countries, The IARIW 33rd General Conference Rotterdam, the Netherlands, August, 24-30.
- [21] Ospina, A. V., Heeks, R. (2010), Unveiling the links between ICTs and climate change in developing countries: A scoping study. International Development Research Centre. Centre for Development Informatics, Institute for Development Policy and Planning (IDPM), University of Manchester. Retrieved from: <http://www.niccd.org/ScopingStudy.pdf>.
- [22] Pade, C., Sewry, D. (2009), the Practice and Need for Rural ICT for Development Evaluation: An Experience of the Siyakhula Living Lab Baseline Study, Proceedings of the 3rd International IDIA Development Informatics Conference, 28-30 October, 81-93.
- [23] Sojudi, S., Aslani Niya, M., Mohseni Zonouzi, F. (2010), The impact of ICT on the environment in developing countries, the fourth Conference of Environmental Engineering, Tehran.
- [24] Stiroh, K. J. (1998), Computers, Productivity, and Input Substitution, *Economic Inquiry* 36(2), 91-175.
- [25] Stiglitz, J. E. (1988), Economic Organization, Information and Development, in H. Chenery And T. N. Srinivasan ed., *Handbook Of Development Economics*, Vol. 1, 93-160.
- [26] Trug, T. (2007), Trade Liberalization and Development in ICT Sector and Its Impact on Household Welfare In Vietnam, DEPOCEN working paper series, No. 2008/34.
- [27] UNCDAT. (2006), *Information Economy Report 2006: The Development Perspective*, United Nations: New York and Geneva.
- [28] UNDP. (2004), *ICT and Human development: Towards Buliding a Composite index for Asia*, 24.
- [29] Wakelin, O. and Shadrach, B. (2001), *Impact Assessment of Appropriate and Innovative Technologies in Enterprise Development* (www.enterprise-impact.org.uk/pdf/ICTs.pdf).
- [30] Williams, E. (2011), Environmental effects of information and communications technologies, *Environmental effects of information and communications technologi*, *Nature International Weekly Journal of Science*, November, 354–358.
- [31] Zhang, X-P., Cheng, X-M. (2009) Energy consumption, carbon emissions and economic growth in china. *Ecological Economics*, 68, 2706-2712.
- [32] Zhao, X., (2005), the dilemma of foreign furniture company in China, *New Economy Weekly*, (16), 84-85.