Columbia Business School

Economic and Social Impact of Broadband and Development of Digital Agendas

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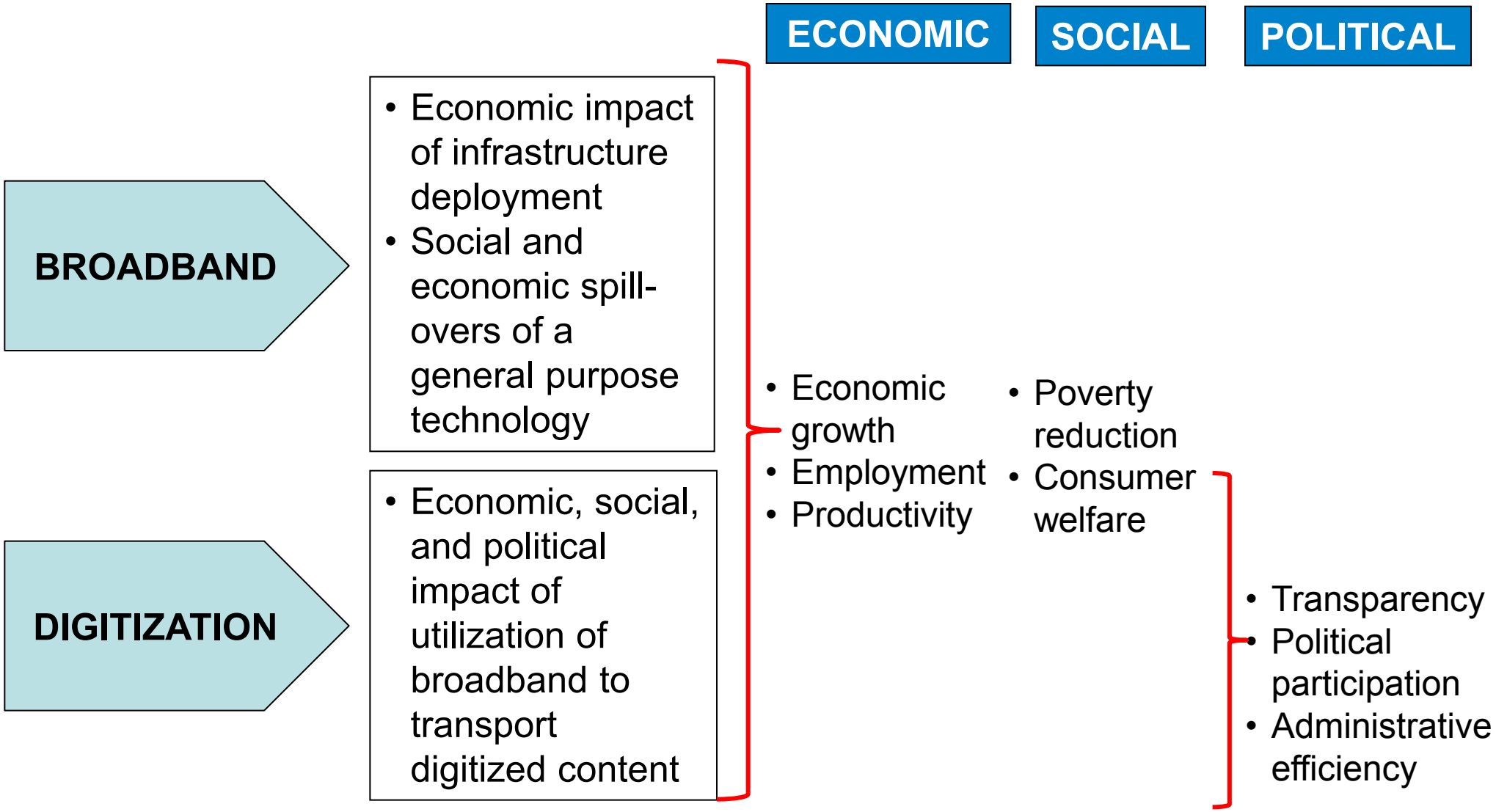
The study of the impact of broadband and digital agendas addresses two distinct phenomena across three dimensions



We will first define the independent variables driving impact and then focus on the three dimensions of impact

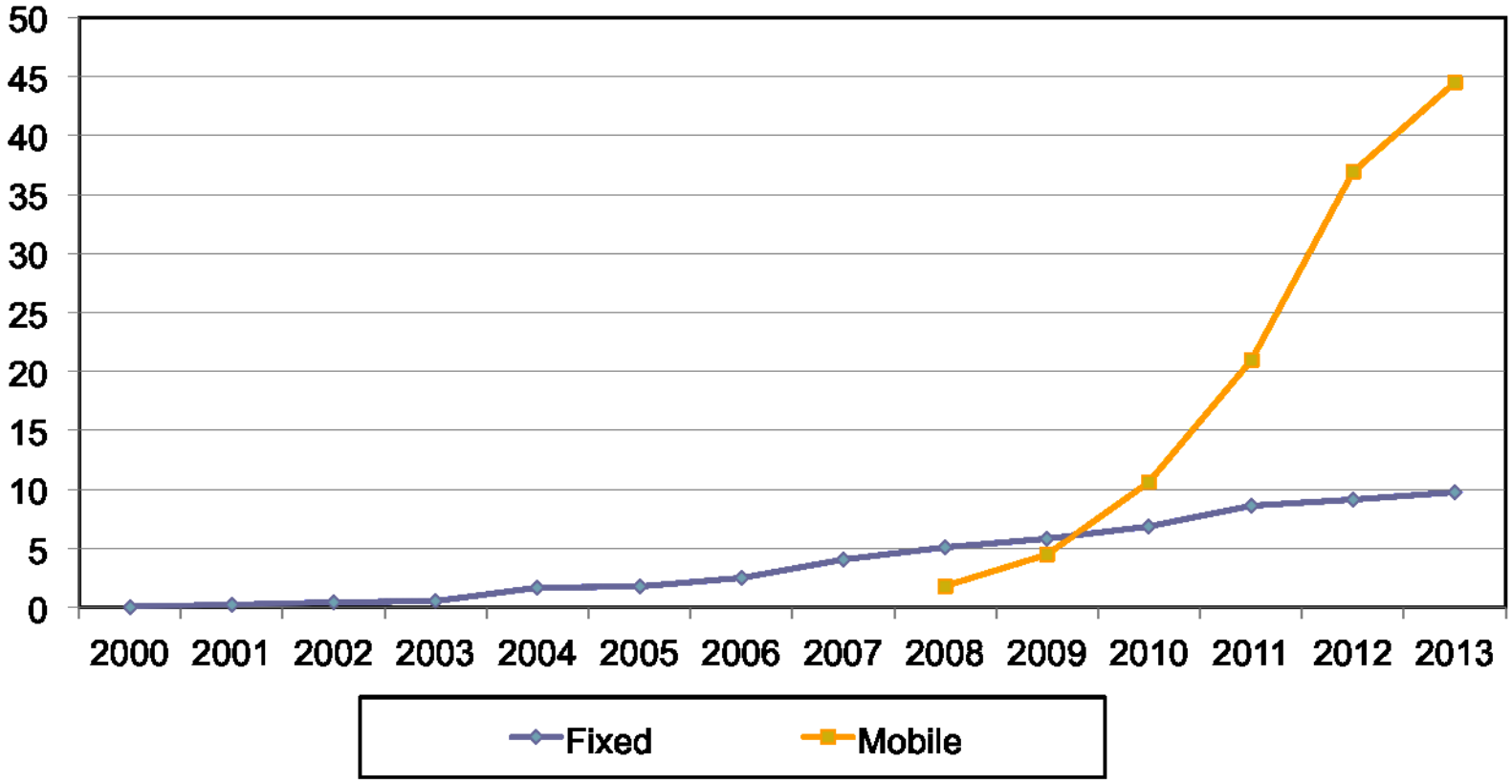
- A refined view of the independent variables: fixed broadband, mobile broadband, and digitization
- Economic impact
- Social impact
- Political impact
- Conclusion

Broadband impact assessment needs to differentiate between fixed and mobile technologies

	ECONOMIC	SOCIAL	POLITICAL
FIXED BROADBAND	• Primary platform for enterprise and government usage • Primary platform for creating /enhancing consumer markets • Household adoption	• Primary platform for enhancing quality of public services (health, education)	
MOBILE BROADBAND	• Primary platform in emerging markets • Individual adoption		• Primary platform for consumer access to information

While fixed and mobile broadband services are part of a single eco-system, their diffusion processes are quite dissimilar

BRAZIL: EVOLUTION OF FIXED AND MOBILE BROADBAND PENETRATION (% POPULATION)
(2000 – 2013)



Source: ITU

Digitization is the capacity to use broadband and other digital technologies to generate, process, share and transact information

- To achieve a significant impact, digitization has to be widely adopted in the economic and social fabric of a given nation
  - Utilized by individuals, economic enterprises and societies
  - Embedded in processes of delivery of goods and services
  - Relied upon to deliver public services
- For this condition to occur, digitization has to fulfill several conditions
  - Affordable: it has to be sufficiently affordable to allow scalable impact
  - Ubiquitous: it is supported by telecommunications networks and reaching most population of a national territory
  - Accessible: networks need to be accessed by multiple fixed and mobile voice and data devices
  - Reliable: networks have to provide sufficient capacity to deliver vast amounts of information at speeds that do not hinder their effective use

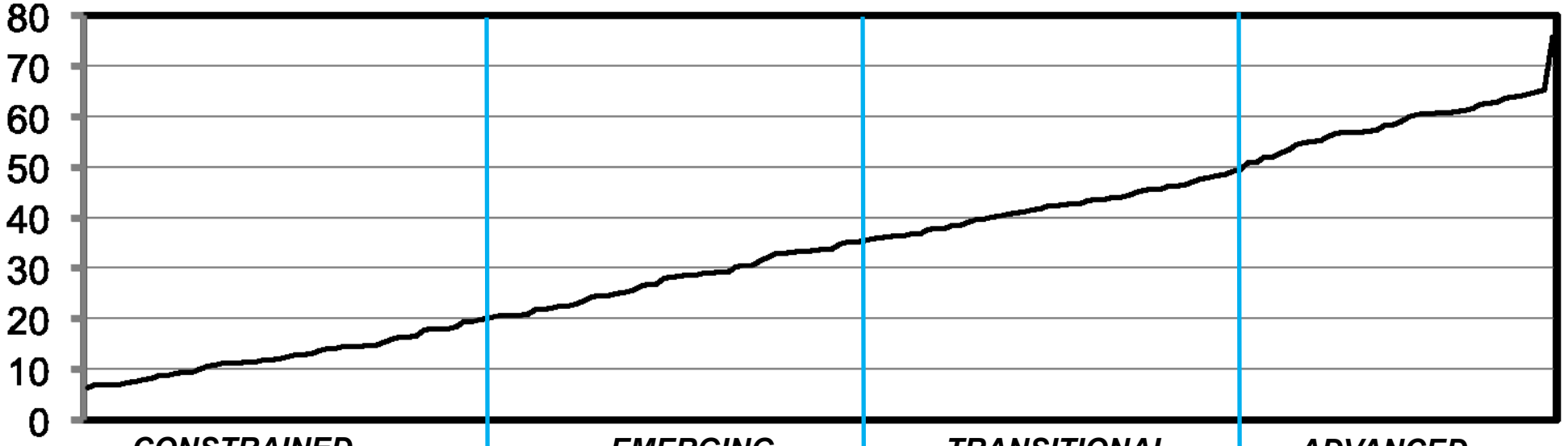
The level of digitization is measured through a composite index which includes infrastructure and utilization metrics

DIGITIZATION INDEX

Indicators	Components	Sub-components
Affordability	Residential fixed line cost adjusted for GDP per capita	Residential fixed line tariff (3 minute call to a fixed line at peak rate) adjusted for GDP per capita
		Residential fixed line connection fee adjusted for GDP per capita
	Mobile cellular cost adjusted for GDP per capita	Mobile cellular prepaid tariff (1 minute call off-net at peak rate) adjusted for GDP/capita
		Mobile cellular prepaid one-time connection fee adjusted for GDP per capita
	Fixed broadband Internet access cost adjusted for GDP per capita	Monthly residential price for a fixed broadband connection
Infrastructure reliability	Investment in telecommunications per telecom subscriber (mobile, broadband and fixed)	Mobile investment per capita
		Broadband investment per capita
		Fixed line investment per capita
Network Access	Network penetration	Fixed Broadband penetration
		Mobile Phone penetration
	Other penetration metrics and coverage infrastructure	Mobile broadband penetration
		PC Population penetration
		Mobile cellular network coverage
Capacity	International Internet bandwidth	International Internet bandwidth (kbps/user)
	Broadband speed	Broadband speed (% of connections with download speed over 2 Mbps)
Usage	Internet retail	Internet retail as percent of total retail
	e-Government	E-government Web measure index
	Individuals using the internet	Percentage of individuals using the Internet
	Non-voice services as % of wireless ARPU	Non-voice (data, message, VAS) spending as percentage of wireless ARPU
	Social network visitors	Dominant Social Network Unique Visitors per month Per Capita
	SMS usage	SMS usage per subscriber
Human Capital	Engineers	Engineers as a percentage of total population
	Skilled Labor	Labor force with more than a secondary education as a percentage of the total labor force

Source: Katz and Koutroumpis (2013)

The index was calculated for 184 countries, indicating that countries tend to follow four developmental stages



CONSTRAINED

- Burundi
- Malawi
- Madagascar
- Central African Republic
- Mali Dem.
- Rep. Congo
- Comoros
- Niger
- Solomon Islands
- Papua New Guinea
- Mozambique
- Afghanistan
- Lesotho
- Burkina Faso
- Zimbabwe
- Uganda
- Myanmar
- Togo
- Vanuatu
- Sierra Leone
- Tanzania
- The Gambia
- Senegal
- Ethiopia
- Sao Tome and Principe
- Rwanda
- Congo
- Cameroon
- Guinea
- Zambia
- Turkmenistan
- Mauritania
- Angola
- Tuvalu
- Lao PDR
- Nepal
- Benin
- Tajikistan
- Timor-Leste
- Ghana
- Samoa
- Nigeria
- Swaziland
- Eritrea
- Cote d'Ivoire
- Djibouti
- Yemen
- Iraq
- West Bank and Gaza
- Nicaragua

EMERGING

- Kenya
- Bangladesh
- VIrgin Islands
- Cambodia
- Cuba
- Tonga
- Guatemala
- Honduras
- Fiji
- New Caledonia
- Bolivia
- Guyana
- Syrian Arab Republic
- Kyrgyz Republic
- Namibia
- Pakistan
- Uzbekistan
- India
- Bhutan
- Gabon
- Sri Lanka
- Cape Verde
- Morocco
- Libya
- Belize
- Vietnam
- Egypt
- Maldives
- El Salvador
- Paraguay
- Trinidad and Tobago
- Sudan
- Albania
- Dominican Republic
- Algeria
- Tunisia
- China
- Macao SAR
- Venezuela
- Jamaica
- South Africa
- Jordan
- Thailand
- Indonesia
- Bosnia and Herzegovina

TRANSITIONAL

- Peru
- Iran
- Lebanon
- Botswana
- Oman
- Seychelles
- Ecuador
- Philippines
- Andorra
- Armenia
- Macedonia
- Azerbaijan
- Brazil
- Antigua and Barbuda
- Dominica
- Bahrain
- San Marino
- Mexico
- Bermuda
- Barbados
- Costa Rica
- Colombia
- Moldova
- Ukraine
- Saudi Arabia
- Montenegro
- Georgia
- Aruba
- Turkey
- Croatia
- Panama
- Brunei
- St. Vincent
- Kazakhstan
- Argentina
- Puerto Rico
- St. Lucia
- Liechtenstein
- Serbia
- Estonia
- Hungary
- Qatar
- Malaysia
- Kuwait
- Taiwan
- Uruguay
- Slovak Republic
- Latvia
- Chile
- Cyprus

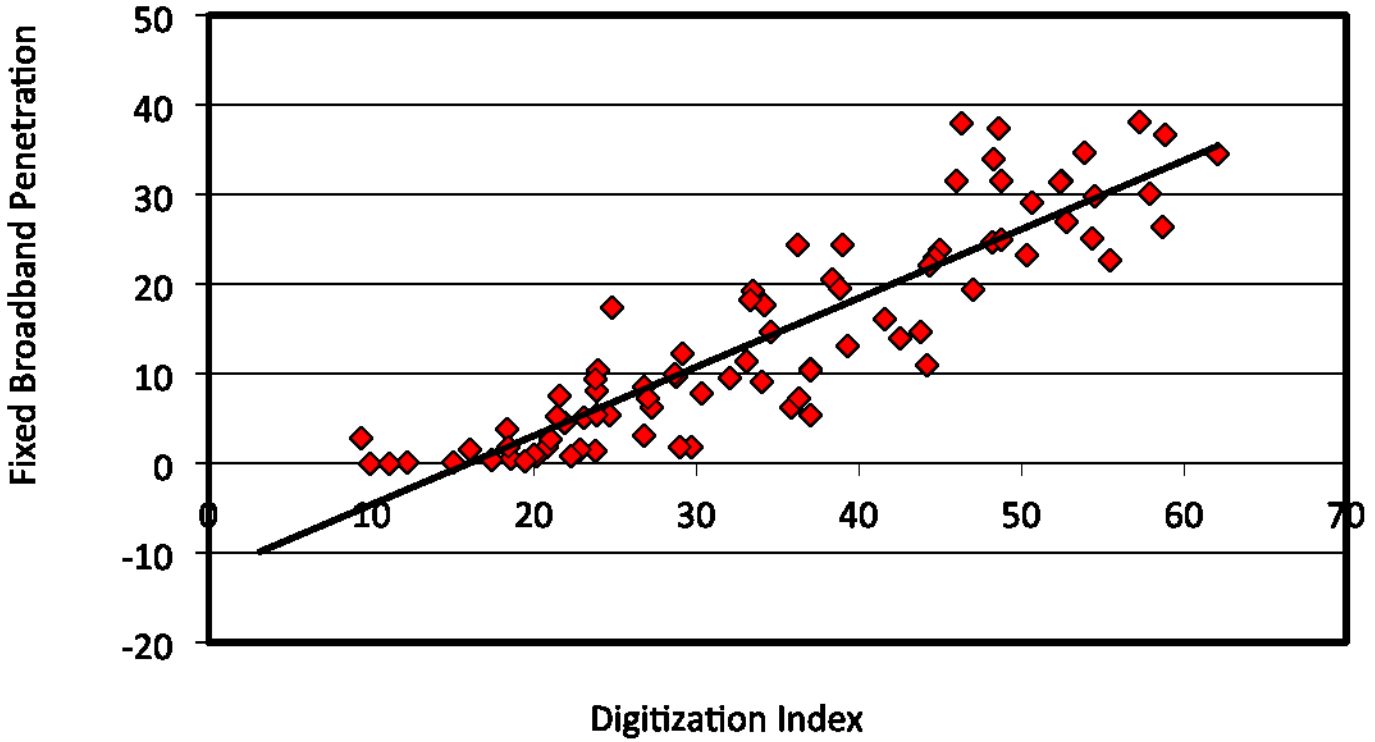
ADVANCED

- Mongolia
- Greece
- Russia
- Poland
- Bulgaria
- UAE
- Italy
- Spain
- Romania
- Lithuania
- Czech Rep.
- Slovenia
- Japan
- New Zealand
- Germany
- Malta
- Mauritius
- Portugal
- Belarus
- Austria
- France
- Singapore
- Iceland
- Netherlands
- Australia
- Belgium
- Ireland
- Hong Kong
- Sweden
- United States
- Luxembourg
- Israel
- Korea
- Switzerland
- Canada
- United Kingdom
- Denmark
- Finland
- Norway

Source: Katz, Koutroumpis, and Callorda (2013)

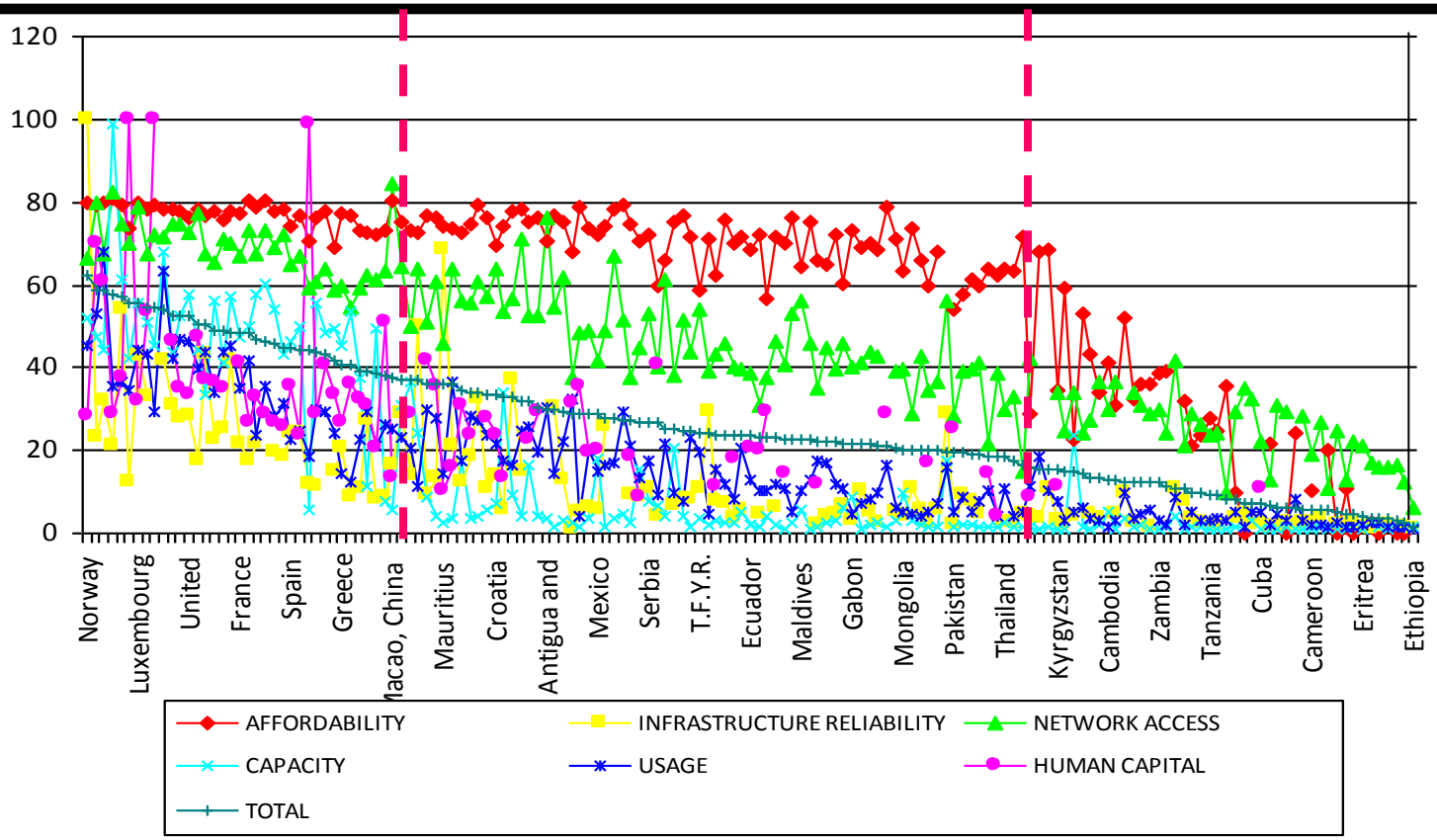
We observe also that, while being highly related to broadband, "digitization is measuring something more than broadband adoption"

DIGITIZATION INDEX VERSUS BROADBAND PENETRATION



Source: analysis by the author

The components of the digitization index also measure a country performance across specific areas



- For all countries, normalized usage sub-index never matches the levels of access sub-indices, which indicate a big challenge across the world
- For all OECD and middle income countries, the sub-indices affordability and network access tend to be consistently above the digitization index indicating that countries have addressed the access challenge
- The affordability and capacity sub-indices tend to rapidly drop at low GDP levels

Having established the distinctions between fixed/mobile broadband and digitization, we now turn to review their respective impact

- A refined view of the independent variable: fixed broadband, mobile broadband, and digitization
- Economic impact of broadband and digitization
- Social impact
- Political impact
- Conclusion

The economic impact of broadband and digitization is comprised of several effects

	Broadband	Digitization
GDP Growth	• Output generated by network deployment (value added, multpliers, ”leaked investments”) • Spill-over effects	• Output generated by direct and indirect effects
Job creation	• Jobs generated by network deployment (direct, indirect, induced) • Spill-over effects	• Jobs generated by direct and indirect effects
Consumer surplus	• Willingness to pay minus price	• Willingness to pay minus price

The infrastructure effect comprises the contribution of investment in network roll-out to GDP and employment

	Broadband	Digitization
GDP Growth	• Output generated by network deployment (value added, multpliers, ”leaked investments”) • Spill-over effects	• Output generated by direct and indirect effects
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Infrastructure effect: Three types of network construction effects exist

EFFECT	DESCRIPTION	EMPLOYMENT EXAMPLES
Direct jobs and output	• Employment and economic production generated in the short term in the course of deployment of network facilities	• Telecommunications technicians • Construction workers • Civil and RF engineers
Indirect jobs and output	• Employment and production generated by indirect spending (or businesses buying and selling to each other in support of direct spending)	• Metal products workers • Electrical equipment workers • Professional Services
Induced jobs and output	• Employment and production generated by household spending based on the income earned from the direct and indirect effects	• Consumer durables • Retail trade • Consumer services

Infrastructure effect: Estimates from several countries indicate that network construction effects and multipliers are significant

NETWORK CONSTRUCTION EFFECTS OF BROADBAND

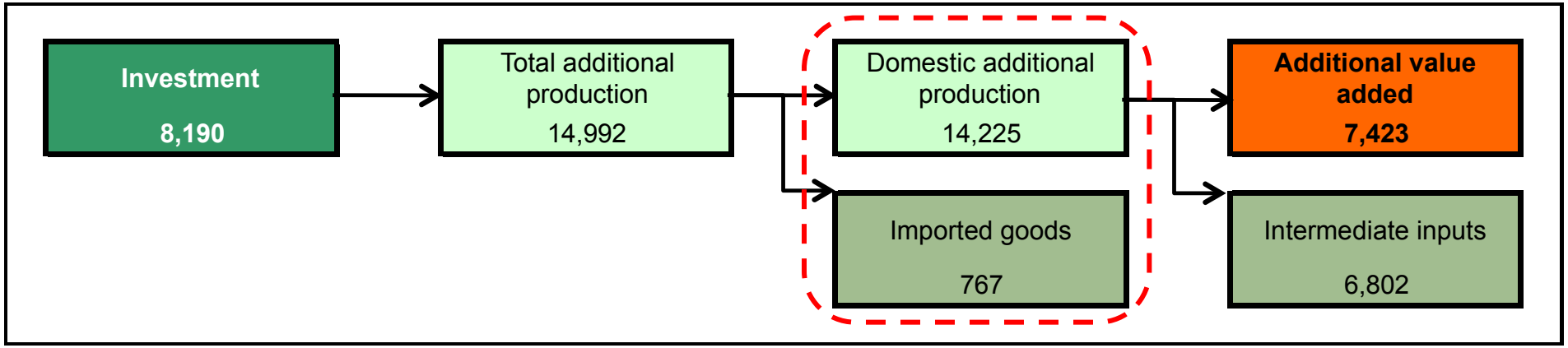
COUNTRY	RESEARCHER / INSTITUTION	STIMULUS INVEST. (US$ million)	NETWORK DEPLOYMENT JOBS ESTIMATE				MULTIPLIERS	
			DIRECT	INDIRECT	INDUCED	TOTAL	TYPE I (*)	TYPE II (**)
UNITED STATES	Katz (Columbia)	$ 6,390	37,300	31,000	59,500	127,800	1.83	3.42
	Atkinson (ITIF)	$ 10,000	63,660	165,815		229,475	2.58	3.60
SWITZERLAND	Katz (Columbia)	~$ 10,000	~80,000	~30,000	N.A.	~110,000	1.38	N.A.
GERMANY	Katz (Columbia)	$ 47,660	281,000	126,000	135,000	542,000	1.45	1.94
UNITED KINGDOM	Liebenau (LSE)	$ 7,463	76,500	134,500		211,000		2.76
AUSTRALIA	Government	$ 31,340				~200,000		
SOUTH AFRICA	Katz (Columbia)	$ 6,006	227,000	102,000	107,000	436,000	1.45	1.92

Sources: Katz, R. and Suter, S. (2009). *Estimating the economic impact of the US broadband stimulus plan, Columbia Institute for Tele-Information working paper;* Katz, R., P. Zenhäusern, S. Suter, P. Mahler and S. Vaterlaus (2008). *Economic Modeling of the Investment in FTTH* in Switzerland, unpublished report; *Libenau, J., Atkinson, R. (2009) The UK's digital road to recovery. LSE and ITIF; Australian government.* Katz, R., S. Vaterlaus, P. Zenhäusern, S. Suter and P. Mahler (2009). *The Impact of Broadband on Jobs and the German Economy*; Columbia Institute for tele-Information working paper

(*) (Direct + indirect)/direct
(**) (Direct + indirect + induced)/direct

Infrastructure effect: the impact on GDP allows estimating the contribution to domestic production versus "leaked" spending

UNITED STATES: NETWORK CONSTRUCTION EFFECTS OF BROADBAND STIMULUS
(in $ millions)



Source: Katz and Suter (2009)

The spill-over effects represent the impact of broadband networks as a general purpose technology, over the whole economy

	Broadband	Digitization
GDP Growth	• Output generated by network deployment (value added, multpliers, ”leaked investments”) • Spill-over effects	• Output generated by direct and indirect effects
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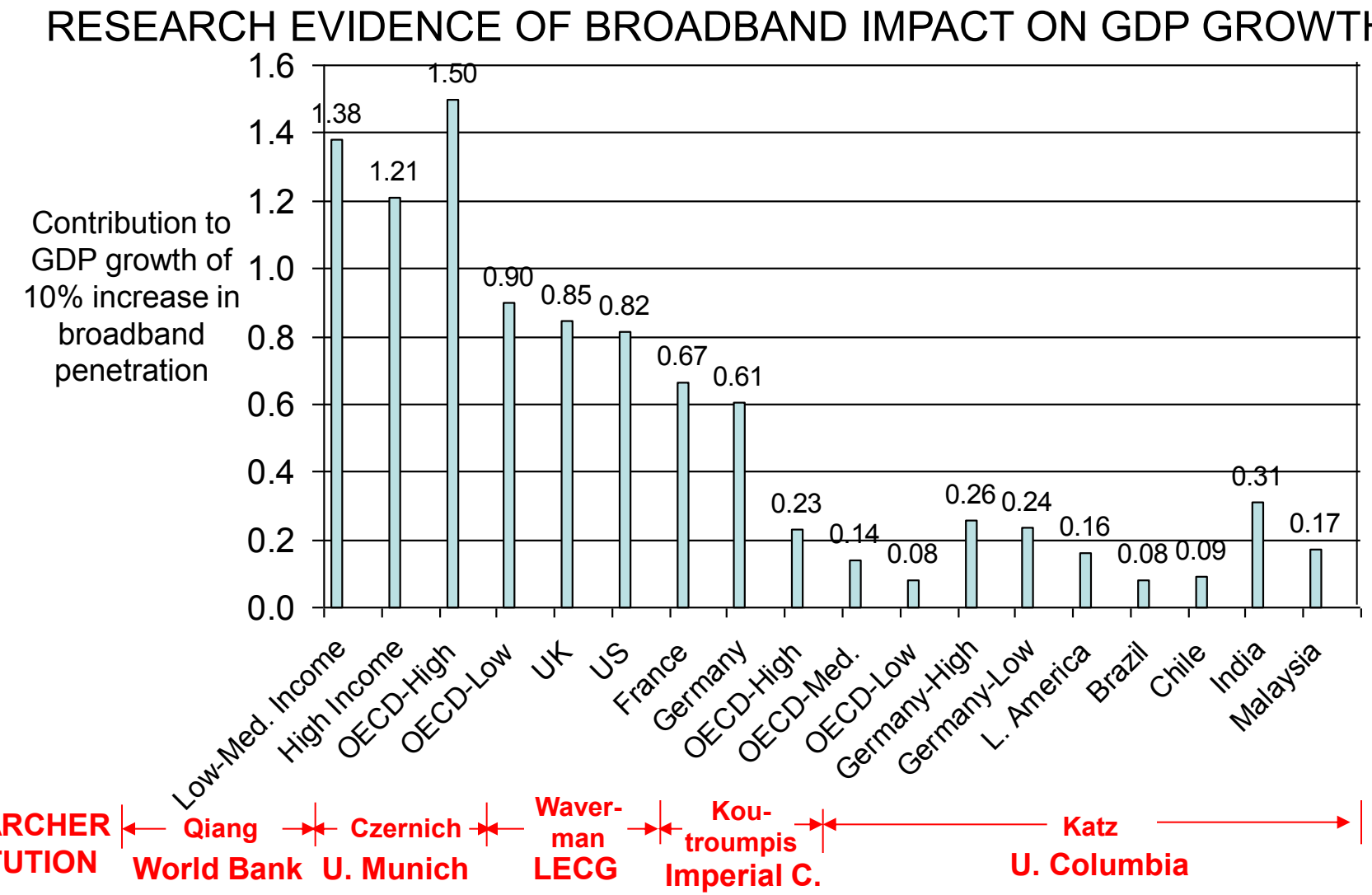
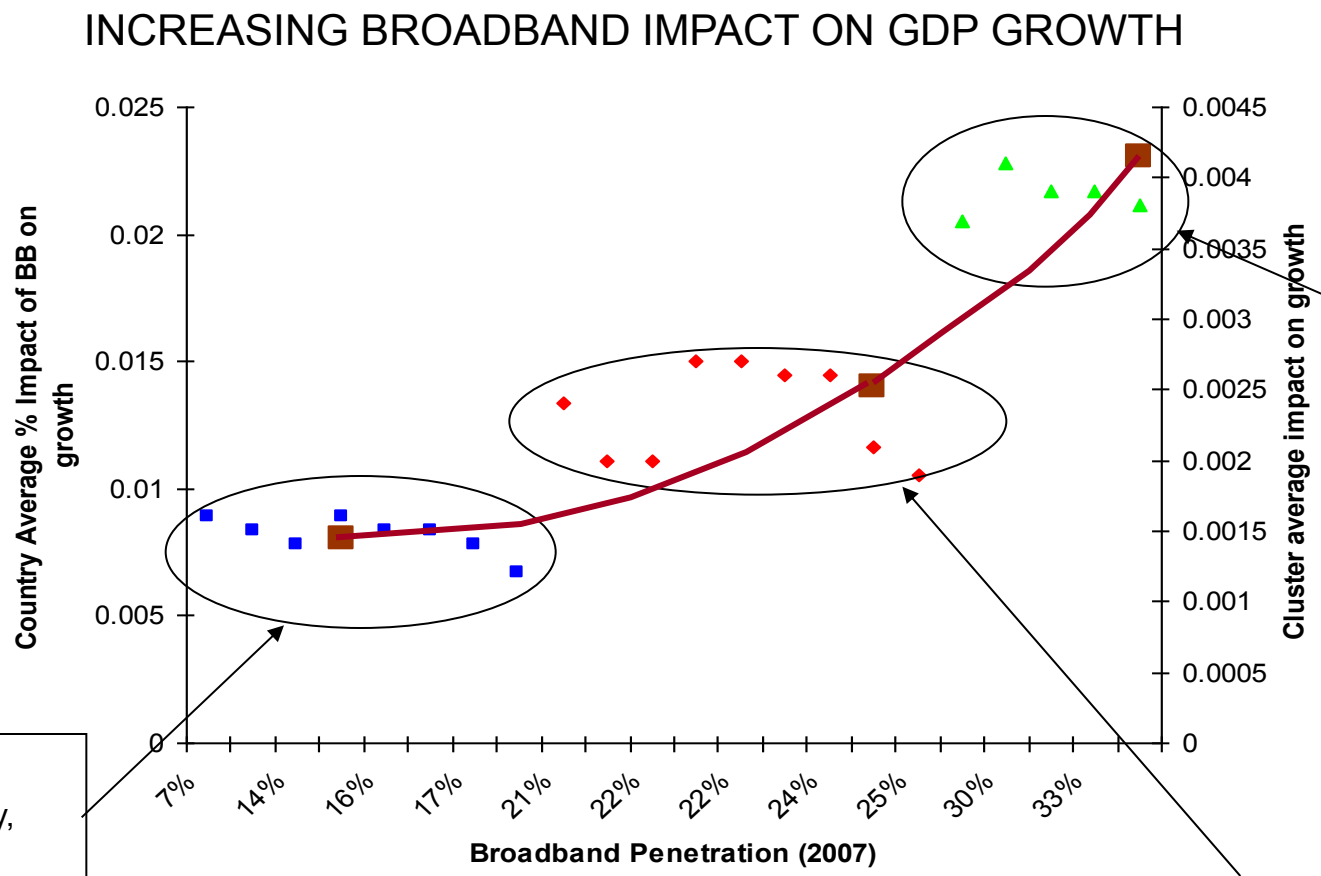
Consumer surplus	• Willingness to pay minus price	• Willingness to pay minus price

Spill-over effects: Research to date confirms the contribution to GDP growth but the amount of impact varies widely



Spill-over effects: The estimates are consistent with growing evidence of increasing returns to broadband penetration



High penetration
- Denmark, Norway, Netherlands, Sweden, Switzerland
- Average contribution to GDP growth: 0.023

Low penetration
- Greece, Portugal, Italy, New Zealand, Austria, Hungary, Spain, Ireland
- Average contribution to GDP growth: 0.008

Medium penetration
- Germany, France, Japan, Belgium, UK, Australia, US, Canada, Luxemburg
- Average contribution to GDP growth: 0.014

Source: adapted from Koutroumpis (2009)

Spill-over effects: In Latin America, fixed broadband contribution to GDP growth is also related to penetration levels

GDP IMPACT OF 1% INCREASE IN FIXED BROADBAND PENETRATION

Country	Type of Model	Period	Number of observations	Impact Coefficient
Panama	Structural	2000-10	40	0.045
Ecuador	Structural	2008-12	17	0.052
Colombia	Simple regression with controls	2006-10	132	0.004

Sources: Katz and Koutroumpis (2012); Katz and Callorda (2013); Katz and Callorda (2011)

Spill-over effects: Mobile broadband economic impact does not appear to be as strong as fixed broadband broadband

SENEGAL: ECONOMIC IMPACT OF WIRELESS BROADBAND

	Variables	Mobile Broadband Model
Growth (GDP)	Fixed Capital Stock	0.632***
	Labor Force	0.960***
	Mobile Broadband Penetration	0.022***
	Constant	-21.742***
Demand (lmbbusers)	GDPC	-1.565
	Mobile Broadband Price	-6.332***
	Competitive Intensity	-2.719***
	Constant	36.994**
Supply (lrevenue)	GDPC	-0.157
	Mobile Broadband Price	0.246***
	Competitive Intensity	-0.252***
	Constant	19.885***
Output (dmb)	Mobile Broadband Revenue	11.687
	Constant	-218.389
Controls	Year Effects	YES
	Quarter Effects	YES
R^2	Growth	0.99
	Demand	0.96
	Supply	0.39
	Output	0.00

Sources: Katz and Koutroumpis (2014)

Less impact than fixed broadband since mobile broadband is not used as intensively in accessing the Internet as fixed broadband

The assessment of digitization economic impact incorporates additional effects related to utilization of the technology

	Broadband	Digitization
GDP Growth	• Output generated by network deployment (value added, multpliers, ”leaked investments”) • Spill-over effects	• Output generated by direct and indirect effects
Job creation	• Jobs generated by network deployment (direct, indirect, induced) • Spill-over effects	• Jobs generated direct and indirect effects
Consumer surplus	• Willingness to pay minus price	• Willingness to pay minus price

An endogenous growth model indicates that the Digitization Index has a positive effect indicating a strong effect on economic output

- Cobb-Douglas function:

$$Y=A_{(t)}(K_{it})^{a}(L_{it})^{b}$$

where:

- $A_{(t)}$ indicates the level of digitization
- K corresponds to fixed capital formation
- L to labor force

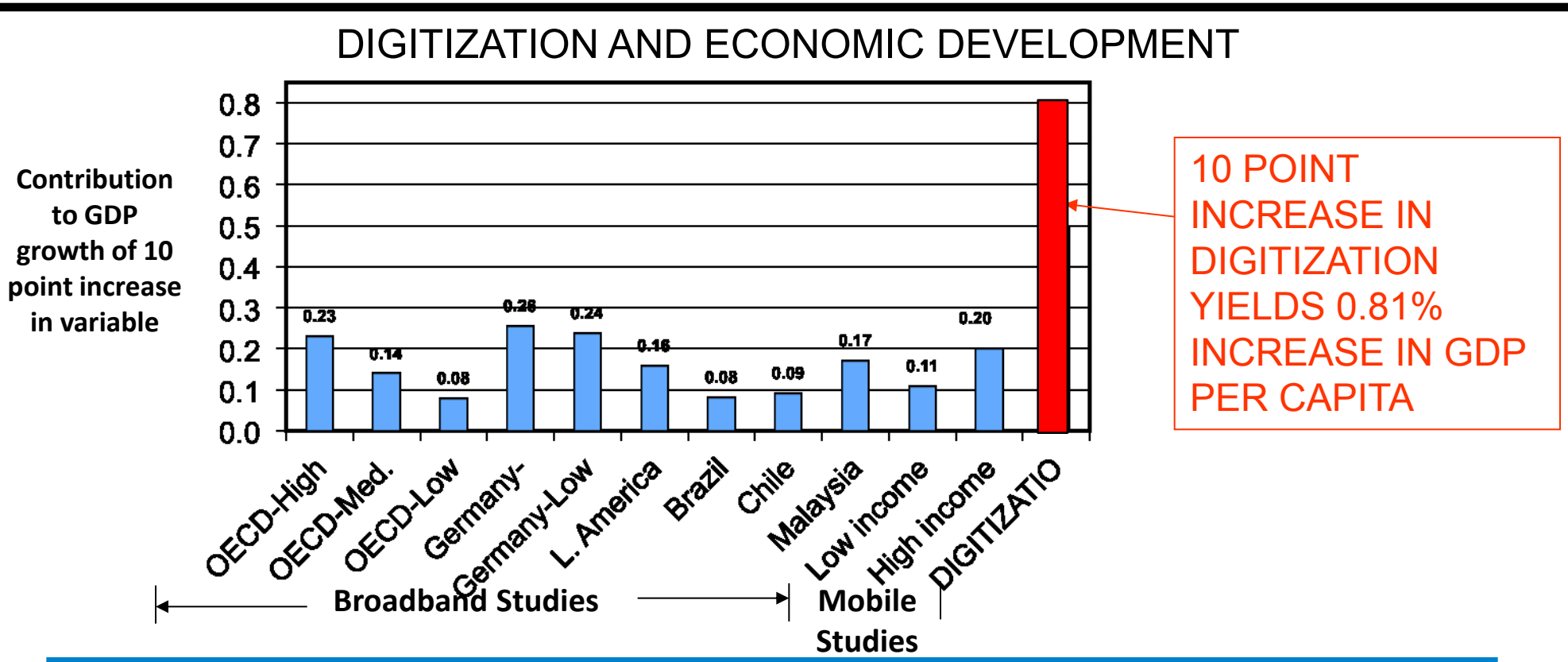
GDP (GDP_{it})	
Fixed Capital Stock (K_{it})	0.1632 ***
Labor (L_{it})	0.1406 ***
Digitization Index (D_{it})	0.0814 ***
Constant	18.23 ***
Year Effects	YES
Country Effects	YES
Observations	783
$R^{-squared}$	0.9051

*** denote statistical significance at the 1% level

$$\log(GDP_{it})=a_1\log(K_{it})+a_2\log(L_{it})+a_3\log(D_{it})+\varepsilon_{it}$$

Source: Katz, Koutroumpis, Callorda (2012)

More importantly, digitization has a higher impact on economic development than broadband alone



- Full economic impact ICT is achieved through the cumulative adoption of all technologies, in addition to the assimilation and usage in the production and social fabric
- Achieving broadband penetration is only one aspect of required policies; maximization of economic impact can only be achieved through a holistic set of policies ranging from telecoms to computing to adoption of internet and eCommerce

The broadband impact on job creation takes place once the networks are deployed

	Broadband	Digitization
GDP Growth	• Output generated by network deployment (value added, multpliers, ”leaked investments”) • Spill-over effects	• Output generated by direct and indirect effects
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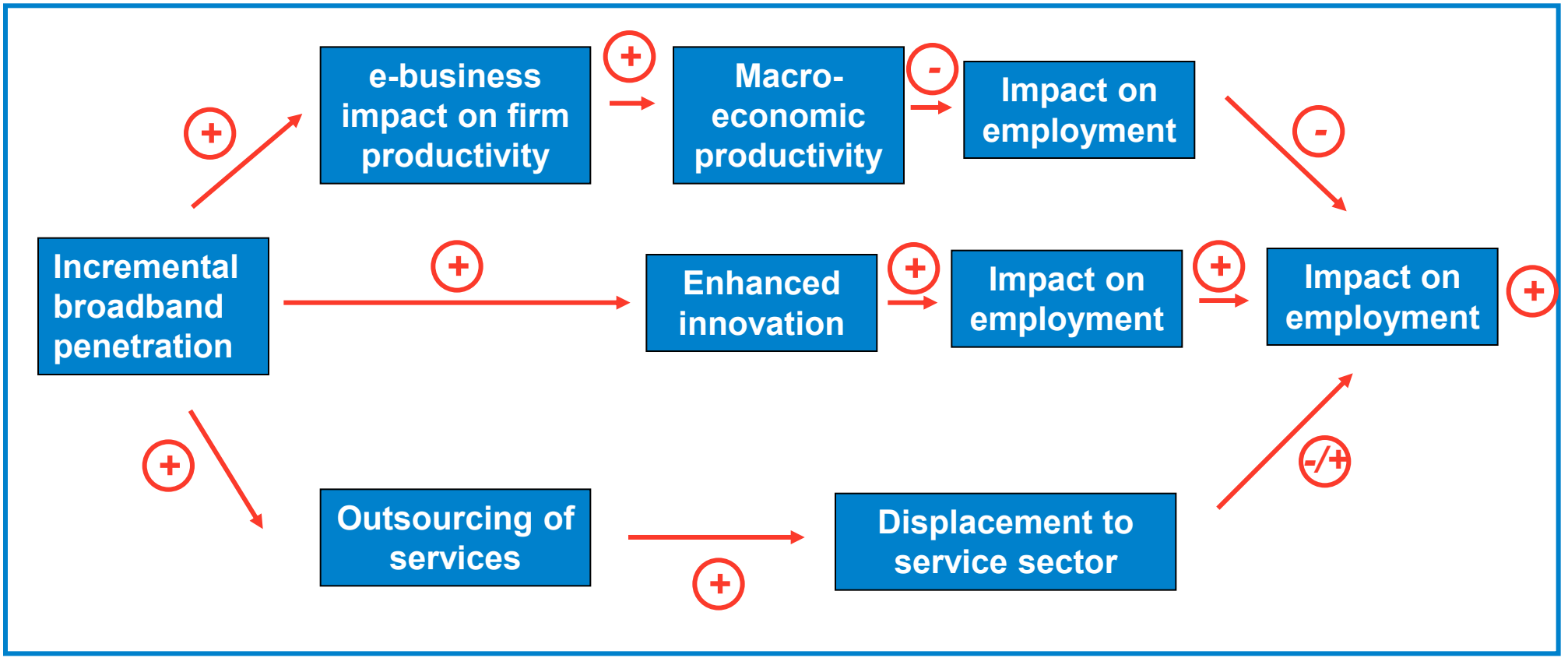
Consumer surplus	• Willingness to pay minus price	• Willingness to pay minus price

Spill-over effects: The contribution of broadband externalities to employment comprises three simultaneous effects



Note: This causality chain was adapted from a model originally developed by Fornefeld et al., 2008 in a report for the European Commission

Spill-over effects: The models do not differentiate between network deployment impact and job creation resulting from spill-overs

ECUADOR: IMPACT OF BROADBAND ON JOB CREATION

Function	Variables	Coefficients
Change in unemployment Rate	Broadband Penetration	- 0,105 *
	Constant	0,758 ***
Change in employment rate	Broadband Penetration	0,056 ***
	Constant	2,559 ***
Year fixed effects		Yes (2008-2011)
Canton fixed effects		Yes (Quito, Guayaquil, Cuenca y otros)
Observations		47
R^2	Unemployment Rate	92,41 %
	Employment rate	98,46 %

*** 1% Statistical significance ** 5% Statistical significance * 10% Statistical significance

Source: Katz, and Callorda (2013)

The digitization impact on job creation also takes place once the networks are deployed

	Broadband	Digitization
GDP Growth	• Output generated by network deployment (value added, multpliers, ”leaked investments”) • Spill-over effects	• Output generated by direct and indirect effects
Job creation	• Jobs generated by network deployment (direct, indirect, induced) • Spill-over effects	• Jobs generated direct and indirect effects
Consumer surplus	• Willingness to pay minus price	• Willingness to pay minus price

According to the models, a 10 point increase in digitization leads to a -.82% change in unemployment rate

DIGITIZATION AND EMPLOYMENT

- Dependent Variable: unemployment rate
- Indepdendent variable: digitization index (D_{it})
- Control variables: Fixed Capital Formation (FC_{it}), Direct Foreign Investment (IED_{it}), population enrolled in secondary schools (proxy of workforce qualification) (ED_{it}), financial services as percent of imports (IFS_{it})

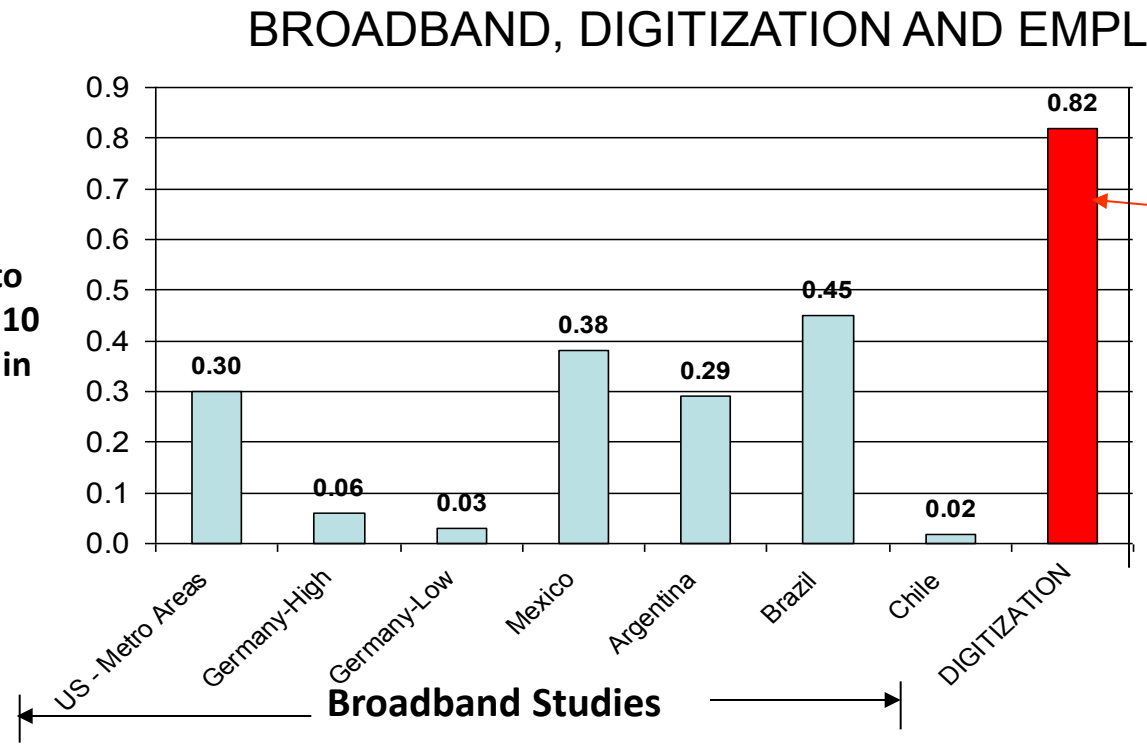
Source	SS	df	MS	Number of obs =	172
Model	421.980167	20	21.0990084	F(20, 151) =	4.17
Residual	764.251026	151	5.06126507	Prob > F =	0.0000
				R-squared =	0.3557
Total	1186.23119	171	6.93702452	Adj R-squared =	0.2704
				Root MSE =	2.2497

unemployment	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
index	-.0823569	.0194742	-4.23	0.000	-.120834	-.0438797
grosscapit~p	-.1422569	.0294456	-4.83	0.000	-.2004354	-.0840784
schoolenro~s	.0144093	.0091293	1.58	0.117	-.0036284	.0324471
foreigndir~w	.1327854	.07197	1.85	0.067	-.009413	.2749837
insurancea~c	-.0438318	.0353308	-1.24	0.217	-.1136383	.0259747

$$\log(Unemployment_{it})=a_1\log(FC_{it})+a_2\log(IED_{it})+a_3\log(ED_{it})+a_4\log(IFS_{it})+a_4\log(D_{it})+\varepsilon_{it}$$

Source: Katz y Koutroumpis (2012)

As in the case of GDP growth, digitization has a higher impact on job creation than broadband



10 POINT INCREASE IN DIGITIZATION YIELDS 0.82% DECREASE IN UNEMPLOYMENT RATE

- Full deployment and assimilation of ICT has a much larger impact on employment because it contributes to more jobs in the ICT sector (software development, Business Process Outsourcing, equipment manufacturing and parts supplies)
- In addition, the impact of assimilation of ICT through enhanced usage has spill-over impact on other sectors of the economy (in particular, trade, financial services, health care)

The consumer surplus estimates are not included in the GDP broadband contribution

	Broadband	Digitization
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Job creation	• Jobs generated by network deployment (direct, indirect, induced) • Spill-over effects	• Jobs generated direct and indirect effects
Consumer surplus	• Willingness to pay minus price	• Willingness to pay minus price

Consumer surplus: utility gain of broadband that can be purchased at a price lower than what consumers are willing to pay

Benefits that broadband technology (DSL, cable modem, Fttx) yields in relation to dial-up

Benefits derived from increased broadband penetration (access to new services and information)

Price declines as a result of competition, technology trends, and productivity gains

Consumer surplus
=
Willingness to Pay
-
Price of service

Having examined the economic impact of broadband and digitization, we now turn to reviewing their social impact

- A refined view of the independent variable: fixed broadband, mobile broadband, and digitization
- Economic impact of broadband and digitization
- Social impact of broadband and digitization
- Political impact
- Conclusion

Broadband has been found to increase average monthly income

ECUADOR: IMPACT ON MONTHLY INCOME (US$ 353.45)

	US$ (Over two years)	Percent increase (over two years)	Annual increase
Increase in individual income for the total sample	US$ 25.76	7.48%	3.67%
Increase for individuals that already owned a computer	US$ 38.36	8.00%	3.92%
Increase for individuals that already were Internet users	US$ 51.86	10.27%	5.01%

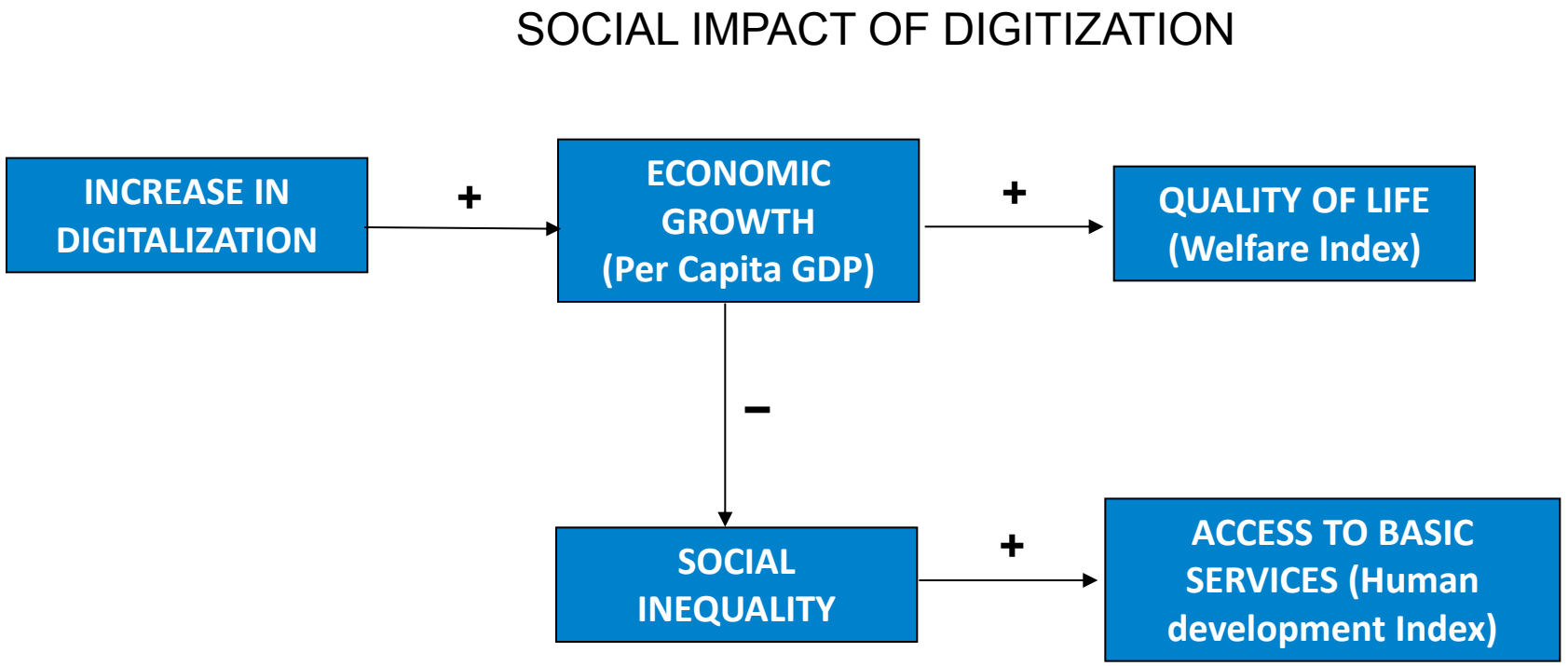
While the overall effect is larger for men than for women, gender difference disappears if Internet was used before broadband had been adopted

Source: Katz and Callorda (2013)

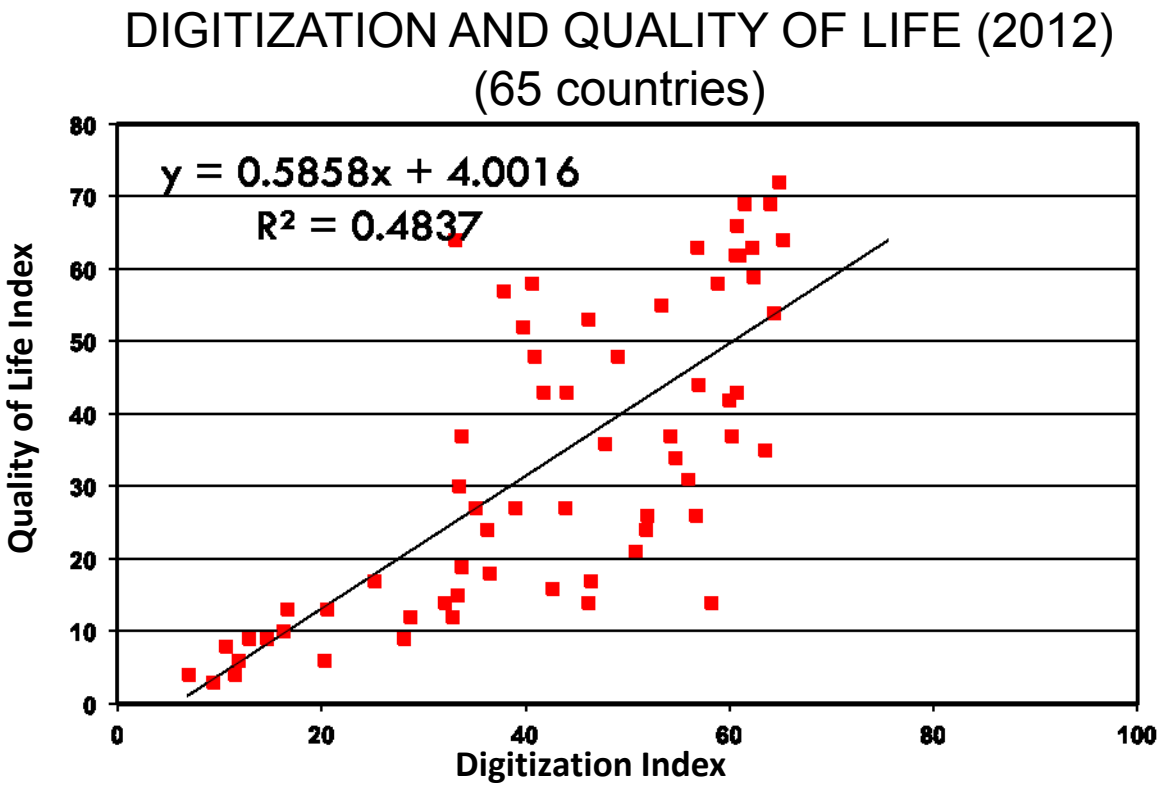
The causal links between broadband and poverty reduction are of four types

- **Infrastructure construction**: Broadband deployment requires additional labor for infrastructure construction, operator's new commercial offices, and technical personnel for installation and maintenance
  - The new demand for labor in a market with an unemployment rate that is already below 5% generates a shift in the demand curve for workers, leading to an increase in equilibrium wages
  - The rise in wages through this channel may reflect a need for better compensation for those workers who, given the low unemployment rates, should receive better wages to meet or exceed their reservation wage
- **Improved labor productivity**: Classic labor economics literature shows that wages in competitive markets equal marginal productivity. As a result, higher labor productivity should yield higher wages
- **Skill "signaling"**: Research shows that the effect of broadband deployment is greater for computer and Internet users. Thus, the introduction of broadband allows workers with digital literacy skills to signal their computer knowledge to potential employers and then use those skills in the workplace in return for a higher wage
- **Reduced search costs**: the introduction of broadband can also help reduce the time required for an effective job search, leading to a reduction in unemployment periods and generating an increase in the migration of underemployed workers to full-time positions, which, in turn, results in higher labor income.

Digitalization also appears to be related to quality of life and other welfare indicators



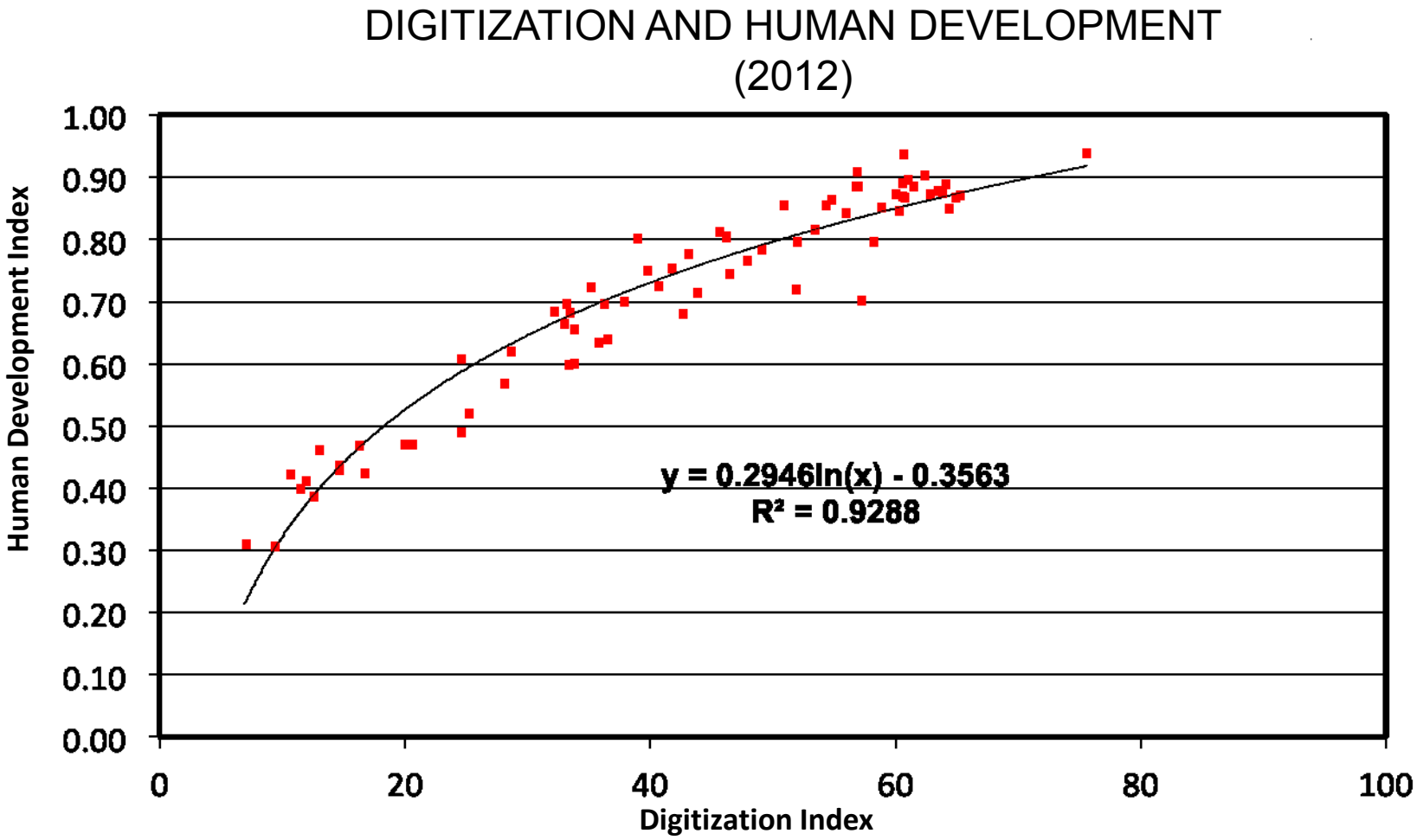
For example, digitalization is directly correlated with quality of life



- The higher the Digitization Index, the higher is the Quality of Life Index
- A correlation for 65 countries indicates that 1 point increase in the Digitization Index leads to an increase of 0.59 points in the Quality of Life Index
- While it is not possible to establish a causal relation, the correlation of both indices is clear

Sources: Gallup (2011); Katz y Koutroumpis (2012)

By reducir inequality, digitization also increases in tandem with the Human Development Index

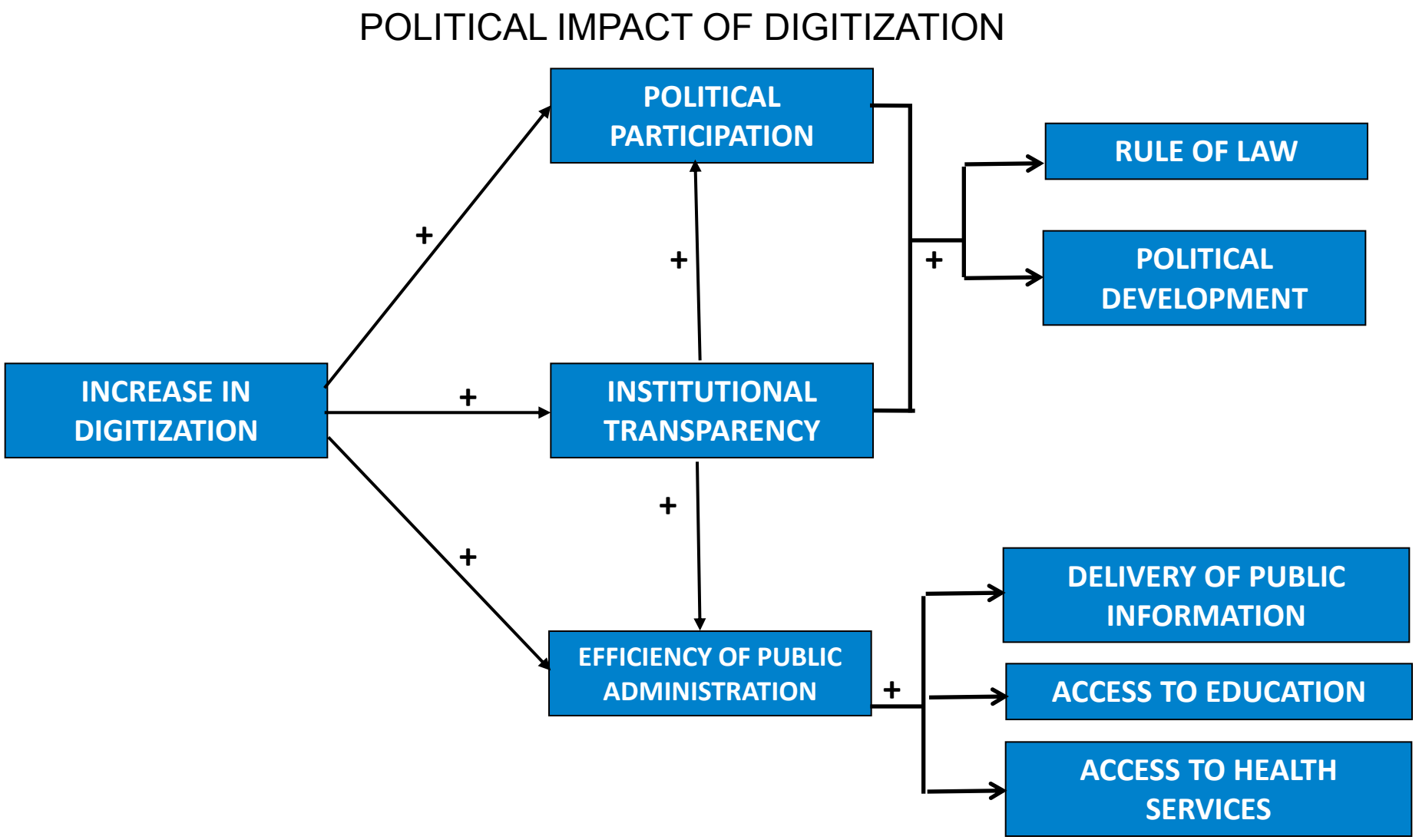


Sources: United Nations (2012); analysis by the author

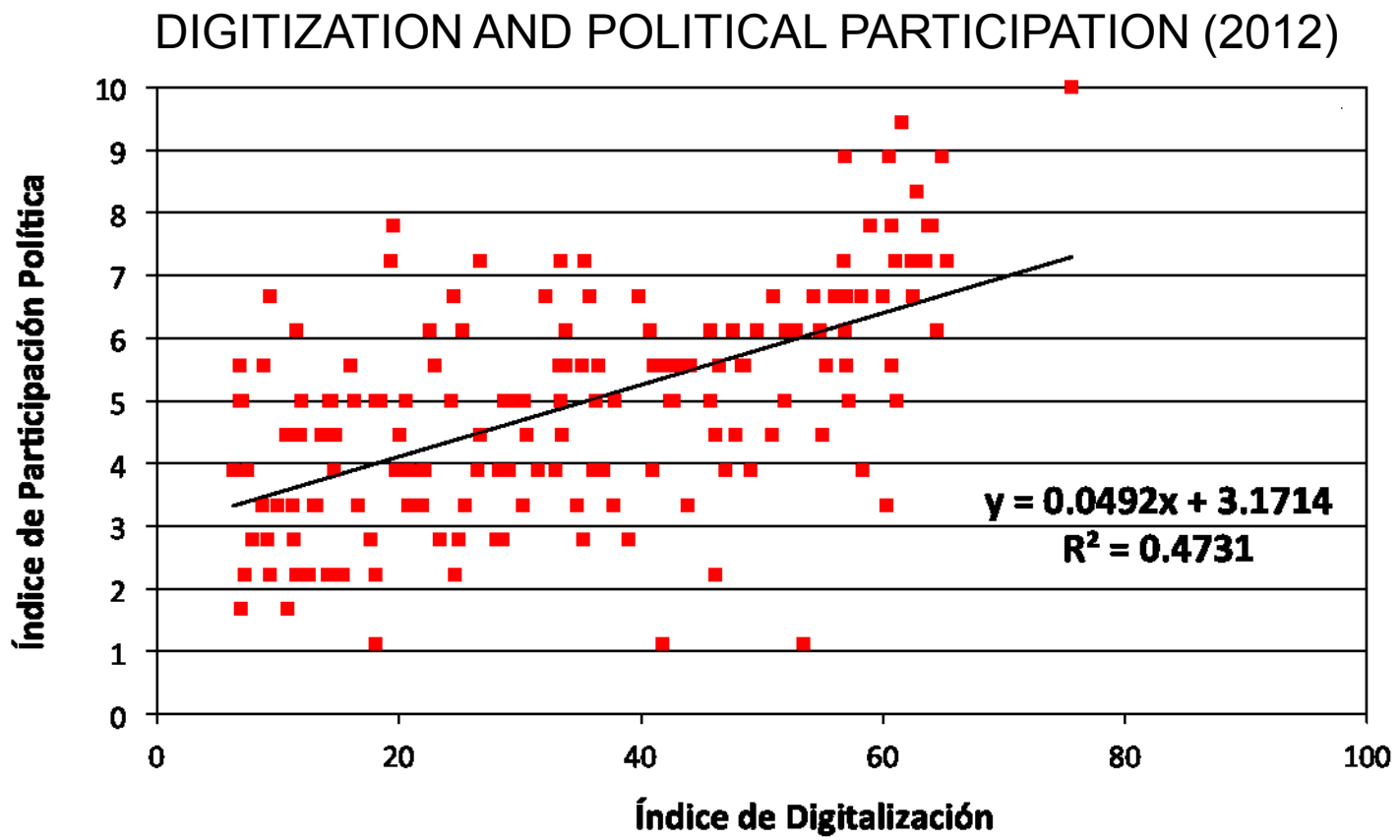
Having reviewed the social impact of broadband and digitization, we now turn to the political impact

- A refined view of the independent variable: fixed broadband, mobile broadband, and digitization
- Economic impact of broadband and digitization
- Social impact
- Political impact
- Conclusion

Digitization is correlated with several dimensions of political development



For example, the higer the digitization index, more intense is political participation

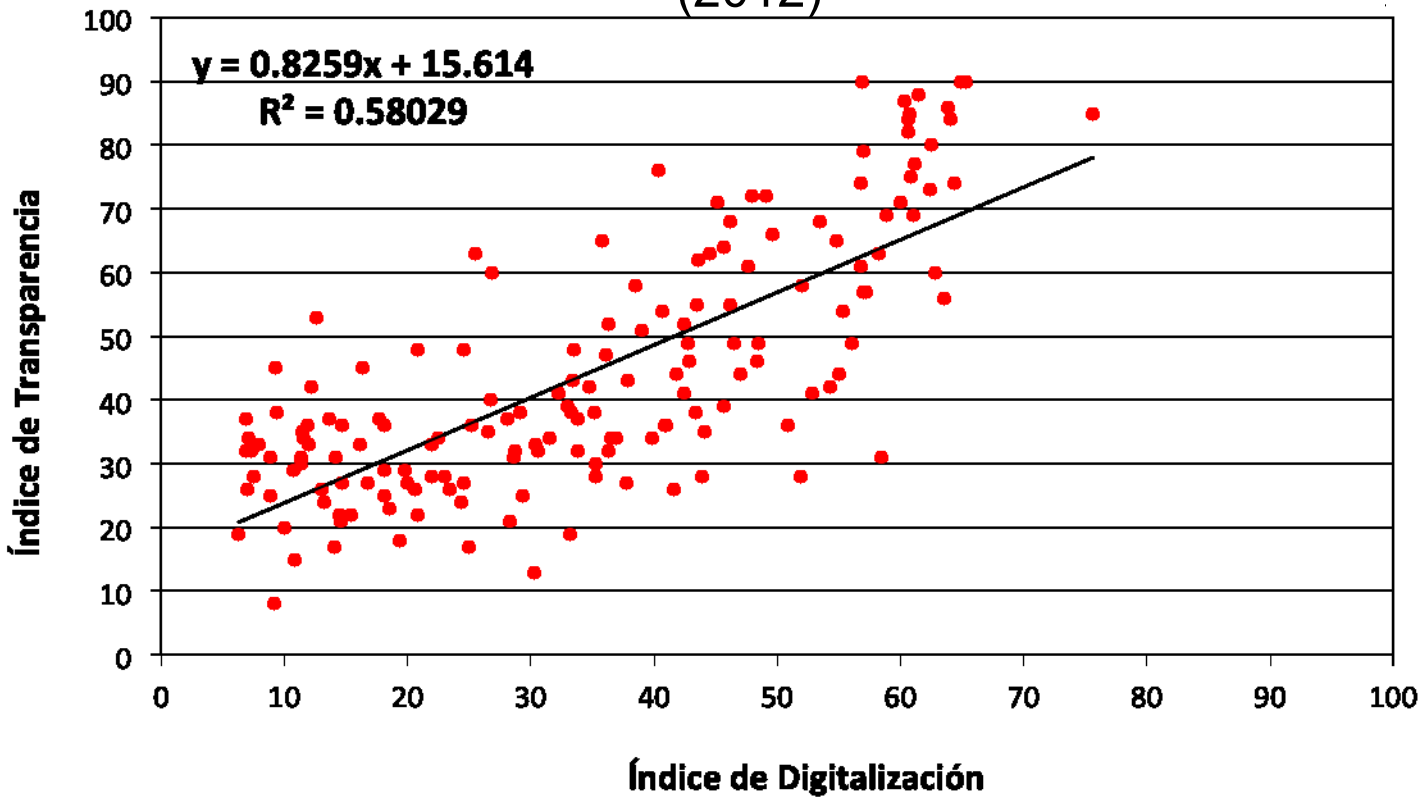


Data used: Participation Index is the result of combining a dicotomic system and a three point score for 60 indicators comprising a democracy index. The participation index is based on 60 questions of the 60 that comprise the democracy index

Sources: The Economist; analysis by the author

In addition, digitization also contributes to institutional transparency

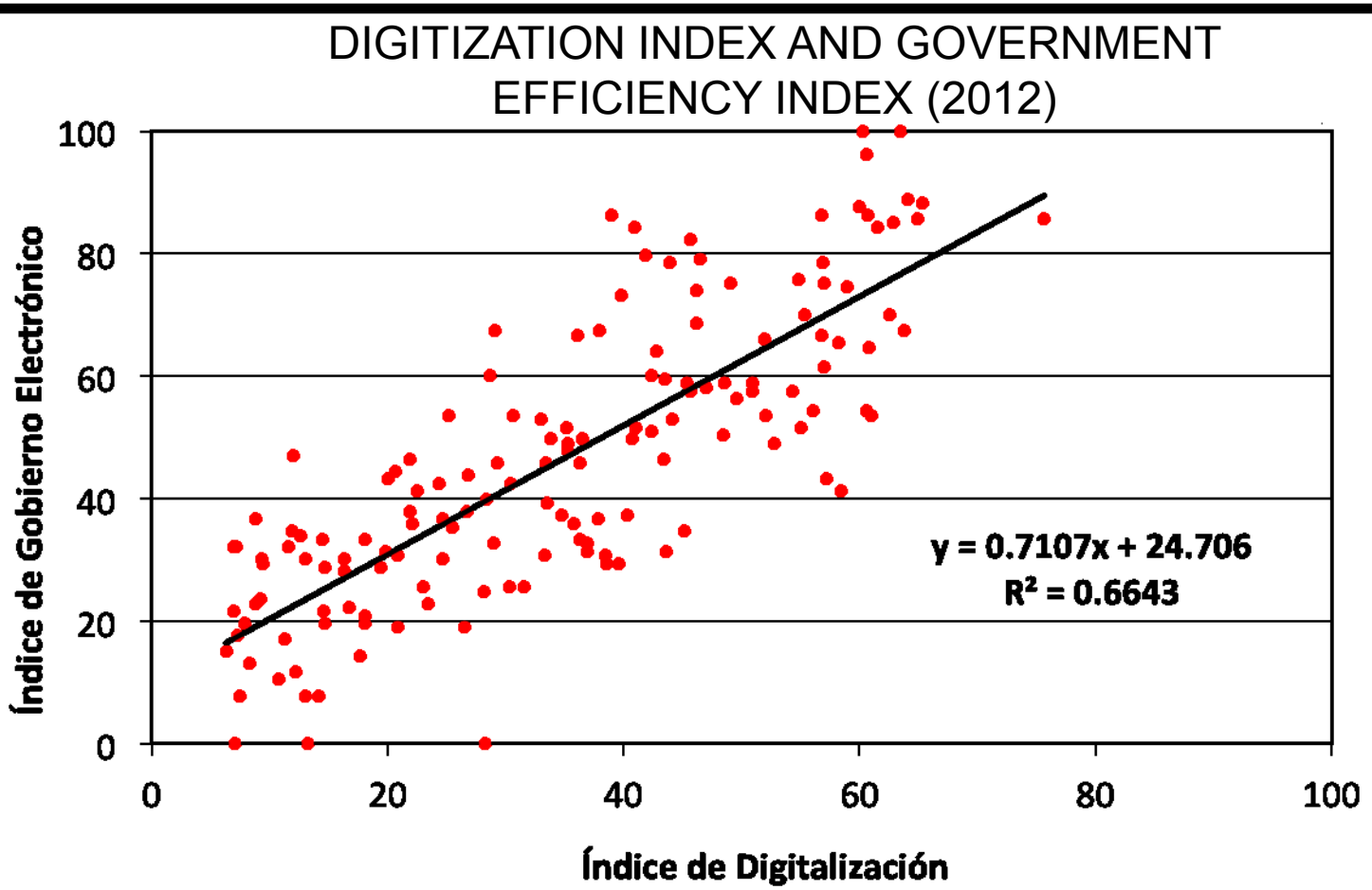
DIGITIZATION AND POLITICAL TRANSPARENCY
(2012)



Note: the Transparency Index developed by Transparency International is calculated by averaging transparency surveys conducted by the World Bank, The Economist, the IMD (Geneva), the World Economic Forum and Freedom House

Sources: Transparency International; analysis by the author

Finally, digitization is correlated with efficiency of government administrations



Note: The e-Government Index measures the quality and utility of government sites to provide information, promote participation and provide public services

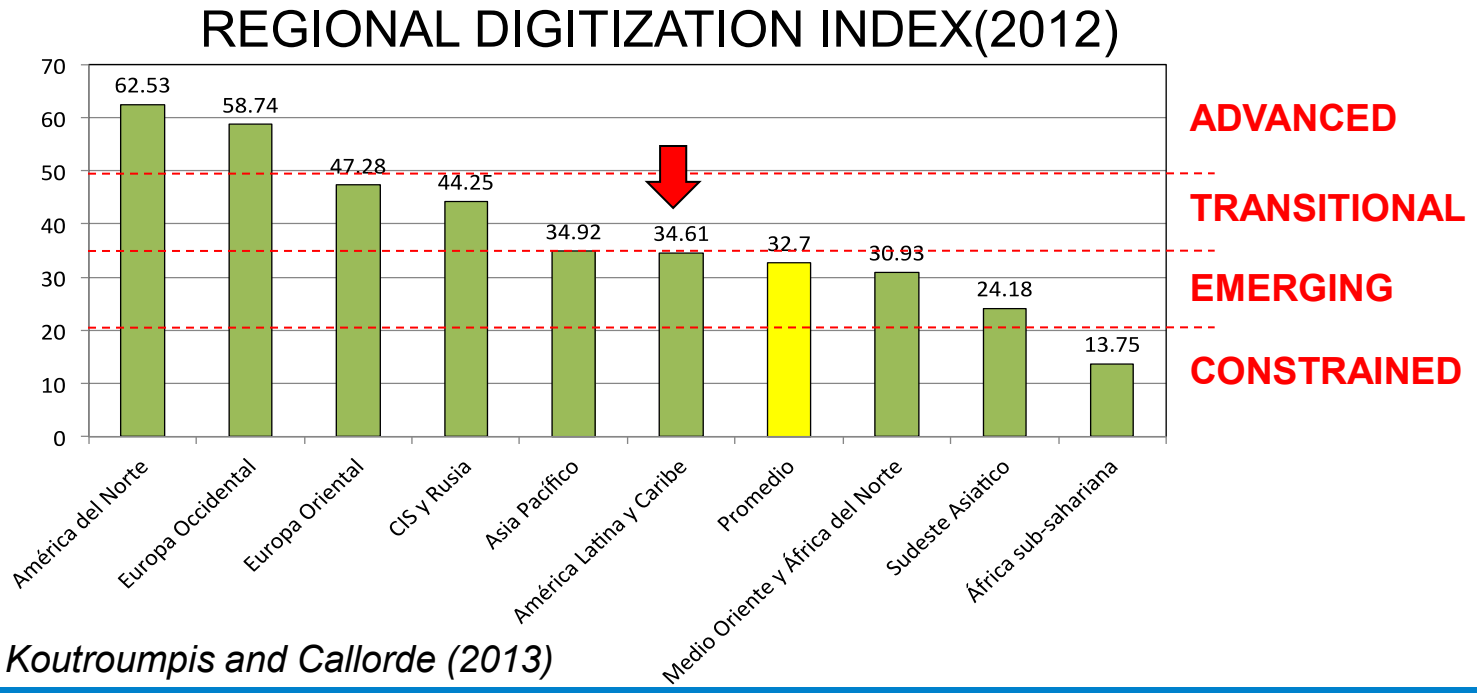
Sources: UNESCO; analysis by the author

In conclusion…

- A refined view of the independent variable: fixed broadband, mobile broadband, and digitization
- Economic impact of broadband and digitization
- Social impact
- Political impact
- Conclusion

The development of broadband and digitization is linked to economic progress, welfare and political development

- Digitization contributes to economic growth, thereby impacting social welfare
- Digitization also has a positive effect on social inclusion and contributes to various dimensions of the political system
- Based on this evidence, the key objective of Latin American and Caribbean countries is to increase their digitization in order to maximize its economic,social and political impact



Source: Katz, Koutroumpis and Callorde (2013)