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Does the digital divide matter ? The role of Information and Communication Technology in cross-country level and growth estimates*

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Does the digital divide matter ? The ICT role in cross-country level and growth estimates

Abstract

The bulk of Information and Communication Technology is made of weightless, implementable and infinitely reproducible knowledge products (such as software and databases). These products are transferred by telephone lines, accessed through internet hosts and processed and exchanged through personal computers.
In this work, the coefficient of the labor augmenting factor in the aggregate production function has been extimated using proxies of variables crucially affecting the diffusion of (non rivalrous and almost non excludable) knowledge products. This specification provides interesting answers to some of the open issues in the existing growth literature. The most recent information, even though available for a limited period, shows that telephone lines, personal computers, mobile phones and internet hosts significantly affect levels and growth of income per worker across countries. The result is robust to changes in sample composition, econometric specification and estimation approach.

1. Introduction

The empirical literature on the determinants of economic growth has progressively tested the significance of factors which were expected to contribute to growth in addition to the traditional labor and capital inputs. In this framework valuable contributions have assessed, among others,[1] the role of: human capital (Mankiw-Romer-Weil, 1992) (from now on MRW), the government sector (Hall-Jones, 1997), social and political stability (Alesina-Perotti, 1994), corruption (Mauro, 1995), social capital (Knack-Keefer, 1997), financial markets (Pagano, 1993; King-Levine, 1992; Wachtel, 2000) and income inequality (Persson-Tabellini, 1994; Perotti, 1996).

The paradox of this literature, though, is that it has left the labor augmenting factor of the aggregate production function unspecified. The impact of technological progress on the differences between rich and poor countries has therefore been neglected. This is the outcome of the implicit assumption that knowledge could be incorporated into production methods as it were a public good, freely available to individuals in all countries (Temple, 1999).

This approach does not properly consider the nature of Information and Communication Technology (from now on ICT) and its role on growth. The core of ICT is made by weightless, expansible and infinitely reproducible *knowledge products* (software, databases) which create value, by increasing productivity of labor or by adding value to traditional physical products and services. Knowledge products are almost public goods. Expansibility and infinite reproducibility make them

[1] Durlauf and Quah (1988) survey the empirical literature on growth and list something like 87 different proxies adopted to test the significance of additional factors in standard growth models. None of them is akin to proxies adopted in this paper to measure factors crucially affecting ICT diffusion.

nonrivalrous, and copyright (instead of patent) protection makes them much less excludable than other types of innovation such as new drugs (Quah, 1999).

Hence, if ICT would consist only of knowledge products, it should be almost immediately available everywhere no matter the country in which it has been created. This does not occur though since the immediate diffusion and availability of knowledge products is prevented by some "bottlenecks". In our opinion these "*bottlenecks*" are: i) the capacity of the network to carry the largest amount of knowledge products in the shortest time, ii) the access of individuals to the network in which knowledge products are immaterially transported and exchanged and iii) the power and availability of terminals which process, implement and exchange knowledge products over the internet.

In this framework, economic freedom and the development of financial markets may affect both ICT diffusion and its impact on growth. Insufficient access provision and excess taxation limit the diffusion of personal computers and internet accesses (Quah, 1999). Liberalisation in the telecommunication sector reduces the costs of accessing the network. Well developed financial markets make it easier to finance projects which aim to implement the capacity of the network and the quality of "pheripherals".[2]

[2] The relationship between ICT and productivity has long been debated over the past three decades. In the 1980s and in the early 1990s, empirical research generally did not find relevant productivity improvements associated with ICT investment (Bender, 1986; Lovemann, 1988; Roach, 1989; Strassmann, 1990). This research showed that there was no statistically significant, or even measurable, association between ICT investment and productivity at any level of analysis chosen.
More recently, as new data were made available and new methodologies were applied, empirical investigations have found evidence that in the second part of the 90es ICT investment was associated with improvements in productivity, in intermediate measures and in economic growth (Oliner and Sichel, 2000; Brynjolfsson and Hitt, 1996 and 2000; Sichel, 1997; Lehr-Licthemberg, 1999; Jorgenson-Stiroh, 2000). The same authors find similar evidence in 2001 despite the 2001 downward revision of the US GDP and software investment and the recession beginning in March 2001 (Oliner and Sichel, 2002; Jorgenson, Ho and Stiroh, 2002).

The omitted consideration of Information and Communication Technology, is partially justified so far by the scarcity of data,[3] but has relevant consequences on the accuracy of growth estimates. Suppose, in fact, that ICT variables are proxies for the diffusion of technology. Then, in the case they are significant and omitted, parameters of the other MRW regressors (labor and investment in physical and human capital) are biased as far as they are correlated with them (*omitted variable critique*). Moreover, (*cross-sectional constant critique*), the omitted specification of the labor augmenting technological progress biases cross section regressions on the determinants of per capita income level. This arises because technological progress cannot be treated as a cross-sectional constant, implicitly attributing the same level of technology to every observation (Islam, 1995; Temple, 1999).[4] The solution of fixed effect panel data (Islam, 1995) is a partial remedy to it as it takes into account unobservable individual country effects. An alternative approach consists in specifying those factors, like ICT in our example, which are expected to be proxies of unobserved country effects.

In addition, the inclusion of ICT variables in the estimate may also avoid that uncontrolled heterogeneity in levels of per capita income lead to a significant correlation between the lagged level of per capita income and the error term in the convergence regressions, thereby violating one of the required assumptions for consistency of OLS estimates (*cross-country heterogeneity critique*).[5]

In this paper accordingly use ICT variables to model the unknown country differences in the diffusion of technology. This approach generates a sharp increase in

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[3] Quah writes in 1999 that "the latest technologies have not been around for very long. Thus, convincing empirical time-series evidence on their impact will be difficult to obtain""

[4] The only relevant exception may be when regressions are run on regions with a certain degree of technological homogeneity such as the US regions in the Barro-Sala-i-Martin (1992) paper on convergence.

[5] According to Evans (1997) this problem can be neglected only when at least 90-95 percent of heterogeneity is accounted for.

the explanatory power of cross-sectional estimates of the determinants of levels of income per worker. Therefore, it significantly reduces the effects of the *cross-sectional constant* and *omitted variable* critiques. The increased goodness of fit in the GDP per worker level regression reduces in turn the effects of the *cross-country heterogeneity* critique making it possible a cross-sectional estimate of convergence in growth rates. The robustness of the main results of the paper (significance of both the initial level and the rate of growth of ICT technology in cross-section and growth regressions) is accurately tested. With bootstrap estimates we find that it is not affected by departures from the normality assumption for the distribution of the dependent variable and we test its robustness to changes in the composition and weight of sample countries. With Generalised 2-Stage Least Squares (G2SLS) panel estimates we find evidence that the ICT-growth relationship is valid also in shorter subperiods and is not affected by endogeneity.

The paper documents all these findings and is divided into four sections (including introduction and conclusions). In the second section we outline our theoretical hypotheses on the role of ICT variables on aggregate growth. In the third section we present and comment empirical tests on our hypothesis.

2.1 The determinants of differences in levels of per capita growth

The considerations developed in the introduction on the role of ICT on growth lead us to formulate the following hypothesis:

Hypothesis 1: factors affecting ICT diffusion are good proxies for measuring the amount technological progress which augments labor productivity in a MRW human capital growth model.[6]

Consider the standard MRW (1992) production function taking into account the role of human capital

$$Y_t = F(K, H, AL) = K_t^{a} H_t^{b} (A_t L_t)^{1-a-b} \qquad \text{with } \alpha + \beta < 1 \tag{1}$$

where H is the stock of human capital, while L and K are the two traditional labor and physical capital inputs.

Physical and human capital follow the standard laws of motion.

$$\begin{aligned} \dot{K} &= s_K Y - \text{ä}K \\ &= s_K F(K, AL) - \text{ä}K \end{aligned} \tag{2}$$

$$\begin{aligned} \dot{H} &= s_H Y - \text{ä}H \\ &= s_H F(K, AL) - \text{ä}H \end{aligned} \tag{3}$$

where s_k and s_h are the fractions of income respectively invested in physical and human capital.

The exogenous growth of the labor input is expressed as

$$L_t = L_0 e^{nt}. \tag{4}$$

Differently from MRW (1992), we model labor augmenting technological progress by assuming that most of it is proxied by weightless, infinitely reproducible, knowledge products (software,databases). These products are conveyed to labor through crucial factors such as the access to the network, the capacity of the network and the availability of “pheripherals” which process and exchange knowledge products.

[6] In the empirical analysis which follows we compare estimates of the MRW base case with those augmented for ICT variables. Hence, in case our hypothesis is rejected, we may discriminate between two alternatives: i) the base case equation fits the data and therefore ICT variables are bad proxies for technical progress; ii) the base case equation does not fit the data and therefore the hypothesis is rejected because the (MRW) model in which conditional convergence is crucially led by human capital is rejected in our sample period.

We accordingly specify the dynamics of technical progress as

$$A_{(t)} = A_{KP(t)}A_{ICT(t)} \tag{5}$$

with $A_{ICT(t)} = A_{ICT(0)}\, e^{gICT(t)}$ and $A_{KP(t)} = A_{KP(0)}\, e^{gKP(t)}$

A_{ICT} is a measure of the stock of ICT factors and g_{ICT} its rate of growth, whereas $A_{KP(t)}$ is the contribution to technological progress of the stock of weightless infinitely reproducible knowledge products and g_{KP} its rate of growth.

By rewriting the production function in terms of output per efficiency units as $y=k^a h^b$, we can obtain the two standard growth equations

$$\dot{k}_t = s_k y_t - (n + g + ä)k_t \tag{6}$$

$$\dot{h}_t = s_h y_t - (n + g + ä)h_t \tag{7}$$

where $g=g_{ICT}+g_{KP}$.

If we set the growth of physical and human capital equal to zero in the steady state we find

$$k^* = \left(\frac{s_k^{1\ â}\quad s_h^{â}}{n+g+ä}\right)^{\frac{1}{1-á-â}} \tag{8}$$

$$h^* = \left(\frac{s_k^{á}\quad s_h^{1\ á}}{n+g+ä}\right)^{\frac{1}{1-á-â}}. \tag{9}$$

Substituting h^* and k^* into the production function and taking logs we obtain

$$\frac{Y}{L} = Af(k^*,h^*) = Ak^{*á}\ h^{*â} = A_{KP(0)}e^{g_{KP}t}A_{ICT(0)}e^{g_{ICT}t}k^{*á}\ h^{*â} \tag{10}$$

and

$$\ln\left(\frac{Y_t}{L_t}\right) = c + \ln\left(A_{ICT(0)}\right) + g_{ICT}t + \frac{á}{1-á-â}\ln(s_k) + \frac{â}{1-á-â}\ln(s_h) - \frac{á+â}{1-á-â}\ln(n+g+ä) \tag{10'}$$

or

$$\ln\left(\frac{Y_t}{L_t}\right)=c+\ln\left(A_{ICT(0)}\right)+g_{ICT}t+\frac{\acute{a}}{1-\acute{a}-\hat{a}}\left[\ln\left(s_k\right)-\ln\left(n+g+\ddot{a}\right)\right]+\frac{\hat{a}}{1-\acute{a}-\hat{a}}\left[\ln\left(s_h\right)-\ln\left(n+g+\ddot{a}\right)\right] \quad (10'')$$

where $c=ln(A_{KP(0)})+g_{KP}t$ is the quasi-public good component of knowledge products and is therefore assumed constant across countries. The difference with the traditional MRW (1992) specification is that we reinterpret the intercept and we add to it two additional terms respectively accounting for the log of the stock of ICT at the initial period and its rate of growth per time unit.[7] Hence, the possibility that all countries have the same steady state level of per capita income doesn't depend only on the leveling of their population growth and broad capital investment rates. It is also affected by both initial stock and growth rate of ICT. A second important difference in this equation is that the country specific rate of growth of technology plus depreciation (*g+d* in all previous models) is no more treated as fixed and equal to 0.05 for all countries[8] (an heroic assumption). In our specification, it varies being crucially influenced by the measured country specific growth rates of ICT.

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2.2 The determinants of differences in convergence of per capita growth

Under hypothesis 1 it is possible to show that, in the proximity of the balanced growth path, *y* converges to *y** at the rate *(1 - a-b) (n+g)° l* This result can be obtained from the solution of the differential equation [9]

[7] Of course alternative specifications could be acceptable as well. For instance, one might argue that ICT is a production factor and should be treated like physical and human capital. The advantage of our approach is that it allows to take into account the interactions between the (rivalrous) ICT and the quasi-public component of technological progress.
[8] This is the approach followed by Solow (1956), Mankiw-Romer-Weil (1992) and Islam (1995) among many others.
[9] This obviously implies that the speed of convergence differs across countries and is crucially influenced by the pace of ICT growth.

$$d\ln(y)/dt=-\lambda[\ln(y)-\ln(y^*)] \qquad (11)$$

which is :

$$\ln(y_t)-\ln(y^*)=e^{-\lambda t}[\ln(y_0)-\ln(y^*)]. \qquad (12)$$

If we add $\ln(y^*)-\ln(y_0)$ to both sides we get an equation explaining the rate of growth:

$$\ln(y_t)-\ln(y_0)=-(1-e^{-\lambda t})[\ln(y_0)-\ln(y^*)].$$

Replacing $\ln(y^*)$ with our solution we get

$$\ln(y_t)-\ln(y_0)=(1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}\ln(s_k)+(1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}\ln(s_h)+ \\ (1-e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) \quad (1-e^{-\lambda t})\ln(y_0) \qquad (13)$$

or

$$\ln((Y/L)(t))-\ln((Y/L)(0))=c'+g_{ICT}t+(1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}\ln(s_k)+(1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}\ln(s_h)+ \\ (1-e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) \quad (1-e^{-\lambda t})\ln((Y/L)(0))+(1-e^{-\lambda t})\ln(A_{ICT(0)}) \qquad (13')$$

where $c'=g_{KP}t+(1-e^{-\lambda t})\ln(A_{KP(0)})$.

The difference with the traditional MRW approach is in the interpretation of the common intercept (which now incorporates the worldwide diffusion of quasi-public knowledge products) and in the fact that convergence may be prevented by differences both in the initial stocks of ICT and/or in their rates of growth.

3.1 Empirical analysis: the database and descriptive statistics

Variables for our empirical analysis are taken from the WDI (*World Development Indicators*) World Bank's database.[10] The dependent variable *Y/L* is the gross domestic product per working-age person converted to international dollars

[10] We cannot use the Penn World Tables as the time period for which we dispose of ICT data does not significantly overlap with that of the Summers-Heston database.

using purchasing power parity rates,[11] L is the number of people who can be economically active (population aged between 15-64). s_k is gross domestic investment over GDP, s_h is the (secondary education) ratio of total enrolment, regardless of age, to the population of the age group that officially corresponds to the level of education shown (generally the 14-18 age cohort).[12] In order to measure factors reducing ICT bottlenecks we consider four different proxies: i) the number of main telephone lines per 1,000 inhabitants;[13] ii) internet hosts (per 10,000 people) or the number of computers with active Internet Protocol (IP) addresses connected to the Internet, per 10,000 people; iii) mobile phones (per 1,000 people); iv) personal computers (per 1,000 people).[14]

Descriptive statistics on the above mentioned variables show that the dependent variable is not normally distributed when we both consider individual year and overall sample datasets.[15] This fact, neglected by the existing literature, should be taken into account when running regressions in levels and rates of growth. Furthermore, simple statistics of sigma convergence clearly confirm that ICT indicators are far from being freely available public goods as the variability in the diffusion of ICT across countries is extremely high and persistent (Fig. 1). On average, for the entire observation period, it is higher when we consider internet hosts, i.e. the latest ICT innovation. Cross-country standard deviation of such variable is two and a

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[11] An international dollar has the same purchasing power over GDP as the U.S. dollar in the United States.
[12] It is also defined as the gross enrolment ratio to compare it with the ratio (net enrolment ratio) in which the denominator is the enrolment ratio only of the age cohort officially corresponding to the given level of education.
[13] Telephone mainlines are telephone lines connecting a customer's equipment to the public switched telephone network. Data are presented per 1,000 people for the entire country.
[14] Since all these factors are expected to ease the diffusion and processing of knowledge products in the internet a qualitative measure of their "power" (i.e. the processing capacity of PCs) would improve the accuracy of our proxies. Unfortunately this information is not available for long time periods and across the countries observed in our sample.
[15] Evidence is omitted for reasons of space and made available from the authors upon request.

half its mean whereas the one of the telephone lines variable is almost equal to its mean.

Tab A.1 in the Appendix provides the list of countries included in the estimates. For each country we display the level of the ICT variable in the first and in the last available year. This table documents that we have data for 115 countries from 1983 if we just consider the diffusion of telephone lines, whereas we can rely on much less countries and more limited time, if we consider the other three ICT indicators. For this reason we define a composed indicator which is an unweighted average of each of the four normalized ICT indicators (when available). We then perform our estimates alternatively with the composed and with each single ICT indicator.

3.2 Econometric estimates of the determinants of levels of income per worker

As a first step we regress equation (1) in levels.[16] Our time span is quite limited when we consider a common starting year for the individual ICT indicators (1991-97), while it becomes much wider when we use the composite indicator. Table 1 compares results from the standard MRW model with the model specified in (1) using different ICT indicators.[17]

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[16] We perform the estimate with four different specifications which alternatively consider: 1) either the ILO labor force or population in working age as labor inputs, 2) either observed income or trend income as a dependent variable. The ILO labor force includes the armed forces, the unemployed, and first-time job-seekers, but excludes homemakers and other unpaid caregivers and workers in the informal sector. We use trend income alternatively to observed income to avoid our results to be influenced by cyclical effects on output (Temple, 1999). Estimates with the alternative proxies for the labor input and the dependent variable do not differ substantially and are available from the authors upon request.

[17] By estimating (10") we implicitly impose the restriction of equality between the coefficient of $log(n+g+d)$ and the sum of coefficients of logs of s_k and s_h. Estimates in which the assumption is removed do not provide substantially different results and are available from the authors upon request.

A first aspect to remark is that elasticities of investment in physical and human capital are, as expected, much smaller on such a limited time span (1991-97) even in the traditional MRW estimate. In spite of this, both factors significantly affect levels of income per worker. The introduction of starting year levels ($A_{ICT(0)}$) and rates of growth of ICT variables (g_{ICT}) significantly improves the overall goodness of fit. Interestingly enough, the model explains almost 94 percent of the cross-sectional heterogeneity when ICT is proxied by the diffusion of personal computers. Both $A_{ICT(0)}$ and g_{ICT} are always strongly significant and show the expected sign.[18] Our estimates indicate an elasticity of .3/.4 of the beginning of period stock of ICT variables ($A_{BR-ICT(0)}$), indicating that a ten percent higher stock of ICT variables at the beginning of the sample period corresponds to a 3/4 percent higher level of per capita GDP.

Furthermore, the four regressors included in (10'') are all significant only when we use the composite index. In almost all other cases the introduction of the ICT variables seems to cast doubts on the significance of the short term elasticity of the investment in physical capital and also on that of human capital when we specify the ICT variable with mobile phones or personal computers.[19] The re-estimation of the model with bootstrap standard errors shows that the significance of the ICT variables remains strong for all the considered indicators and robust to changes in the composition of sample countries.[20]

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[18] Our results obviously risk to be affected by endogeneity. We will discuss this issue in the rest of the paper. In the meanwhile it is worth considering that the dependent variable is measured in the last year of the sample interval, all other regressors are time sample averages and $A_{ICT(0)}$ is measured in the first sample year and therefore lagged at least thirteen years with respect to the dependent variable.

[19] The weakness of the human capital variable when we introduce personal computers is consistent with the hypothesis that the productive contribution of skilled workers passes through (or is enhanced by) the technological factor. For evidence on this point see Roach (1989), Berndt et al. (1992) and Stiroh (1998).

[20] Remember that bootstrapping provides an alternative way of estimating standard errors which does not rely on any a priori given distributional form (Efron, 1979, Efron and Stein, 1981; Efron and Tibshirani, 1986). More specifically, in each trial of the bootstrapping procedure we draw with replacement N observations from the N observation dataset (therefore in each trials some countries

A final estimate done by using the composite index on the 1983-1997 time range suggests what happens when we extend the estimation period and when regression coefficients measure medium and not short term elasticities. Magnitudes of physical and human capital investment coefficients are now higher and closer to those found in MRW. A striking result is that s_k is no more significant when ICT variables are included in the estimate, while s_h is significant with an implied *b* of *.23*.[21] This number is below the range calculated by MRW for the US.[22] Overlooking differences in the estimation periods, the first result seems to suggest that the physical capital contribution falls when we properly consider the role of ICT factors (which, in a broad sense, are part of physical capital). In the same original MRW (1992) estimate the physical capital factor share drops from 0.41 in the overall sample to 0.14 in the OECD sample. This change may be explained in the light of our results given the higher contribution of ICT technology to output in the first group of countries. Further support for this hypothesis comes from the Jorgenson-Stiroh (2000) empirical paper documenting the dramatic decrease in the selling and rental price of computers in the USA, paralleled by an increase in the same prices for physical capital between 1990 and 1996 and attributing to high firm and household input substitution elasticity part

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may have higher weight and other countries may not be included in the sample). We perform two thousands of trials and for each of them we calculated the coefficient magnitude. The estimate of the standard error of that statistics then depends on the variability of the estimate in the different trials. In this sense, and given that in each trial of the bootstrapping procedure we draw with replacement N observations from the N observation dataset, bootstrapping measures the sensitivity of the result to changes in the number of observations. We also estimate the model separately for OECD and non OECD countries and find that the ICT effect is significant in both subsamples, even though it appears to be stronger in OECD countries. Results are omitted for reasons of space and available upon request.

[21] The lack of cross-sectional significance of s_k can be anticipated even by the simple inspection of descriptive statistics. If we divide our sample into three equal subgroups of countries according to levels of income per worker (high, medium and low income) we find that values of s_h are respectively 83.60, 58.92 and 50.46 percent, while values of s_k are much more equal across subgroups (23.57, 23.18 and 23.00 percent)

[22] According to MRW which compare minimum wage to average manufacturing wage in the US, the human capital factor share should be between 1/2 and 1/3.

of the change in the relative contribution to growth of the two different types of capital.[23]

Output elasticities of the two ICT variables, when included in our estimate, seem therefore to reduce the output elasticity of human capital and to obscure the cross-sectional contribution of physical capital. They significantly contribute, though, to explain large differences in income per capita which would remain partially unexplained would the role of ICT be neglected. A plausible rationale for this finding is that part of the contribution of human capital to output depends on ICT.[24] The former is overstated if the latter is not accounted for.

The use of a cross-sectional regression to estimate the determinants of levels of per capita income has been strongly criticised by Islam (1995). His argument is that the labor augmenting A-factor in the aggregate production function represents country specific preferences and technological factors. It is therefore not possible to assume that it is absorbed in the intercept and therefore constant across countries (*cross-sectional constant critique).* Our estimate partially overcomes the problem by specifying the technological variable. On the other hand, we need to take into account the reasonable possibility that some additional country specific variables (deep fundamentals such as *ethos* or governance parameters such as economic freedom) are omitted. We therefore consider two alternative solutions: i) a re-estimation of (1) as a cross-section with the introduction of variables which may proxy for those omitted; ii)

[23] The same shift in technological patterns induced by the ICT revolution seems to be an autonomous cause of substitution between ICT and physical capital since ICT investment modifies the trade-off between scale and scope economies. The literature finds that ICT investment fosters the change from a Fordist to a flexible, less-capital intensive, network productive model (see the discussion on the introduction of CAD/CAM technology in Milgrom-Roberts, 1988) in which products and processes are more frequently adapted to satisfy consumers' taste for variety (Brooke, 1991; Barua-Kriebel-Mukhopadhyay, 1991; Becchetti-Londono-Paganetto, 2000).

[24] For instance, it is reasonable to figure out that higher word processing capacity or the possibility of exchanging information in internet increases the productivity of high skilled more than that of low skilled workers.

a panel estimate of the same equation in which fixed effects[25] capture all additional country specific variables.[26]

With respect to the second approach suggested to overcome the *cross-sectional constant critique,* fixed effect panel results confirm the robustness of the significance of the technological variable (Table 2).[27] Our results are a direct answer to Islam (1995) interpretation of country specific fixed effects in its MRW-type panel estimate. In his specification, country specific technology effects are significantly and positively correlated with GDP growth rates and human capital. Since our ICT variables are positive and significant and their inclusion reduces the impact of human capital they are formally (in definition) and substantially (in data) a relevant part of the fixed effects measured by Islam (1995).

This type of estimate, though, generates an endogeneity problem since the contribution of ICT is no more split into the two components of initial levels and rates of growth and is therefore not completely lagged with respect to the dependent variable. To overcome the endogeneity problem we use the G2SLS methodology which combines fixed effect panel estimates with instrumental variables.[28] We use two to four periods lagged values of ICT indicators as instruments and find that ICT variables are still significant (Table 2). The ICT elasticity in panel estimates is smaller (.02/.12) than the corresponding elasticity in cross-sectional estimates. This

[25] The fixed effect is preferred to the random effect approach as the second retains the strong assumption of independence between regressors and the disturbance term.

[26] With respect to the first approach we perform a sensitivity analysis à la Levine-Renelt (1992) adding to their variables indexes of economic, civil and legal freedom. Results show that all regressors of specification (1) are substantially robust (no change in significance and limited change in magnitude) to the inclusion of any combination of the above mentioned additional explanatory variables. Evidence is omitted for reasons of space and is available from the authors upon request.

[27] Panel estimates are robust to the sensitivity analysis performed also on cross-sectional estimates. Evidence is omitted for reasons of space and is available from the authors upon request.

[28] Our decision to use generalized 2-stage least squares instead of GMM hinges on a recent result of Erickson (Econometrica, 2001) showing that "The main advantage of GMM is its well known covariance matrix formula rather than its efficiency with respect to TSLS…the difference between GMM and TSLS

roughly corresponds to the cross-sectional coefficient since the sample period is divided into five subperiods and therefore we calculate in the panel estimate the effect in a smaller time interval.

3.3 Econometric estimates of convergence in rates of growth of income per worker

The reduced interval for which we dispose of ICT data limits our analysis to short-medium term convergence and prevents us to estimate convergence with panel data. Nonetheless, since the best specification of (10'') explains almost 94 percent of the observed cross-sectional heterogeneity our attempt at estimating convergence with a cross-sectional estimate is not severely affected by the *cross-country heterogeneity critique* (Evans, 1997). The results we obtain are roughly in line with the existing literature and with our theoretical predictions formulated in section 2. Table 3 shows that our ICT-growth model performs better than the MRW model in the 90es. The level of income per working-age person in the starting period (Y/L_{1985}) becomes significant only if we proxy the labor augmenting technological progress with our ICT variables. The effect of ICT on growth is quantitatively smaller than that on levels with a .06/.13 elasticity (a ten percent higher stock of ICT variables at the beginning of the sample period corresponds to a .6/1.3 percent higher rate of growth in the considered period). Thus, short-run convergence doesn't appear to be conditional only on investments in physical and human capital,[29] it also depends on ICT investments.[30]

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estimates is likely to be small." Therefore, the difference between the two approaches is only in the computational simplicity of the variance-covariance matrix.

[29] The lack of significance of the coefficient of human capital is a well known result in the literature. Islam (1995) explains it by arguing that the positive cross-sectional effect of human capital is likely to be outweighted by the negative temporal effect (higher levels of investment in human capital did not

Convergence is also slightly larger when we introduce ICT variables. In interpreting our result of faster convergence it is necessary to warn that we are working on a reduced and almost non overlapped sample period with respect to MRW (1983-1997 against 1960-1985). In this period convergence looks faster when it is conditioned to variables relevant in our model.

Sensitivity analysis shows that our results are confirmed even when we use bootstrap standard errors (considering either the composite ICT index or the PC diffusion variable as proxies of ICT). Moreover, they are robust to the inclusion of three by three combinations of all additional variables used in Levine-Renelt (1995) plus several different indicators of quality of institutions and macroeconomic policies.[31]

Conclusions

The technological revolution originated by the progressive convergence of software and telecommunications and fostered by the advancements in digital technology is dramatically changing the world. This revolution has sharply reduced transportation costs, deeply modified geographical patterns of productive factors across the world and significantly increased the productivity of human capital.

We believe that Information and Communication Technology mainly consists of a core of reproducible and implementable knowledge incorporated in quasi-public "knowledge products" such as software and database libraries which can be accessed

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produce positive changes in growth). This is not the case for ICT investment which is shown to have also positive time effects in our estimate.

[30] If we arbitrary set (n+d + g) equal to 0.05 for all countries our implied l is larger than that in MRW and lower than in Solow (1956) and in Islam (1995).

[31] Evidence is omitted for reasons of space and made available from the authors upon request.

by everyone at some conditions. These conditions are represented by capacity and access to the network and by the availability of efficient terminal nodes which allow to process, exchange and reproduce these knowledge products. Domestic growth, therefore, is likely to be also affected by the quality of telephone lines and by the number of personal computers, mobile phones and internet hosts. These factors are in fact able to reduce bottlenecks which may limit the diffusion of technological knowledge.

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The empirical literature on growth has so far neglected this phenomenon for lack of the available information or under the theoretical assumption that technology is a public good which can be easily incorporated without costs into domestic aggregate production functions. Our empirical evidence demonstrates that this is not the case and finds . Even though for a more limited time span than in traditional empirical analyses our results support the theoretical prediction of a significant role of ICT diffusion in explaining levels and rates of growth of income per worker. Moreover, they show that the ICT factor is an additional crucial determinant of convergence in levels as well as in growth rates. These findings are robust to changes in specification, sample composition and in the estimation approach.

Our conclusion is that ICT diffusion is necessary to understand conditional convergence. It bridges the gap between pessimistic concerns that cross country differences in income are structural and are going to persist and even widen on one hand, and optimistic views believing that those who lag behind will be able to catch up on the other hand. By collecting additional information on ICT diffusion in the next years we will be able to know whether ICT contribution to growth is likely to persist also in the future so that our conclusions may be extended to a longer time period.

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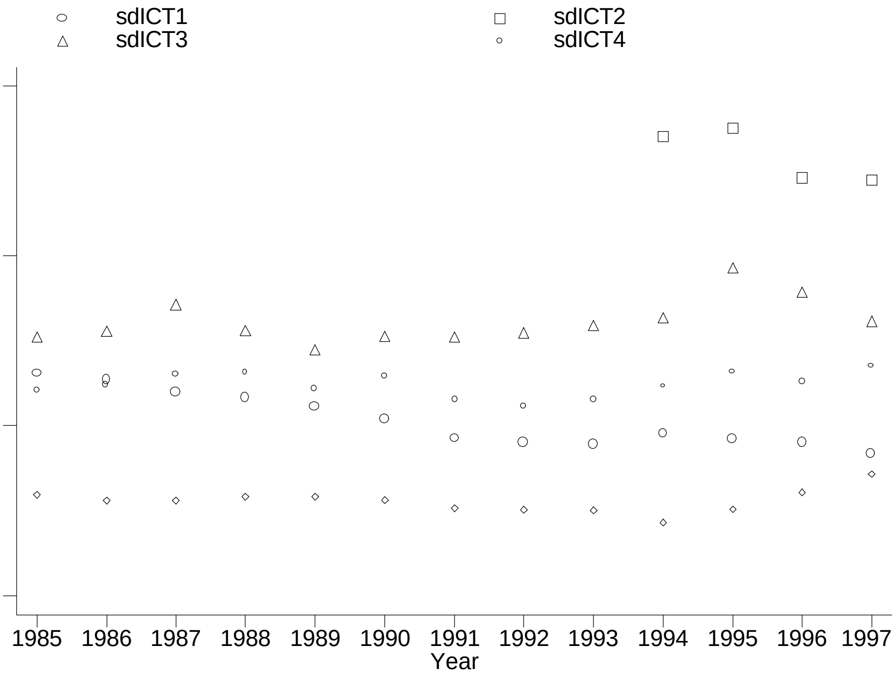
Fig. 1: Sigma convergence of ICT indicators (standard deviation to mean ratios)



Note: sdICT1: standard deviation/mean ratio of main telephone lines per 1.000 people; sdICT2: standard deviation/mean ratio of internet hosts (or the number of computers with active Internet Protocol (IP) addresses connected to the internet) per 10,000 people; sdICT3: standard deviation/mean ratio of mobile phones (per 1,000 people). sdICT4: standard deviation/mean ratio of personal computers (per 1,000 people). The last symbol represents sdICT (COMPOSITE INDEX): unweighted average of ICT1, ICT2, ICT3 and ICT4.

Tab. 1 Cross-section regressions with and without ICT indicators.

	(1991-1997)					(1983-1997)	
	MRW-TYPE ESTIMATE	EQUATION (1) WITH ICT1	EQUATION (1) WITH ICT3	EQUATION (1) WITH ICT4	EQUATION (1) WITH THE COMPOSITE INDEX	MRW	EQUATION (1) WITH THE COMPOSITE INDEX
$Ln(s_k)-ln(n+g+d)$	0.017	-0.003	-0.008	0.008	0.003	0.363	0.086
	[2.280]**	[-0.430]	[-1.260]	[1.610]*	[0.540]	[2.060]	[0.63]
$ln(s_h)-ln(n+g+d)$	0.025	0.004	0.004	0.002	0.007	0.895	0.322
	[18.240] **	[1.820] **	[1.750]*	[0.880]	[3.380] **	[12.560]**	[3.69]**
$g_{ICT}t$		0.240	0.118	0.230	0.174		0.299
		[2.080] *	[3.000] **	[2.220] *	[4.550] **		[8.03] **
$ln(A_{ICT(0)})$		0.451	0.301	0.438	0.388		0.302
		[10.180] *	[10.050] **	[12.690] **	[9.970] **		[8.48] **
CONSTANT	6.982	7.066	9.000	7.779	8.905	1.171	6.733
	[35.920] **	[51.590] **	[31.940] **	[31.180] **	[38.780] **	[1.480]	[7.76] **
R^2	0.799	0.9127	0.877	0.939	0.9127	0.772	0.874
Implied α						0.160	--
Implied β						0.395	0.242
Countries	94	88	47	47	94	100	99

Note: the Table reports results on the estimation of equation (1). In the second to fourth column the traditional MRW approach is augmented with ICT variables. ICT1: main telephone lines per 1.000 people. ICT3: Mobile phones (per 1,000 people). ICT4: Personal computers (per 1,000 people); ICT COMPOSITE INDEX: unweighted average of ICT1, ICT2, ICT3 and ICT4 where ICT2 is the number of computers with active Internet Protocol (IP) addresses connected to the internet) per 10,000 people. g is $g_{ICT}+g_{KP}$, where g_{ICT} is the growth rate of the selected ICT variable, and g_{KP} is assumed constant across countries. s_h , s_k and $g_{ICT}t$ are calculated as estimation period averages, while the dependent variable has the end of period value. T-stats are reported in square brackets. ** 95 percent significance with bootstrap standard errors, * 90 percent significance with bootstrap standard errors. We use the percentile and bias corrected approach with 2000 replications.

Tab. 2 The determinants of levels of income per worker estimated with panel data fixed effects and G2SLS fixed effects

	PANEL FIXED EFFECTS					G2SLS (FIXED EFFECTS)			
	MRW-type estimate	ICT1	ICT3	ICT4	C. index	ICT1	ICT3	ICT4	C. index
$ln(s_k)-ln(n+g+d)$	0.155	0.111	0.137	0.155	0.166	0.103	0.177	0.140	0.205
	[5.760]	[5.200]	[3.850]	[4.060]	[6.090]	[4.760]	[4.330]	[3.200]	[5.280]
$ln(s_h)-ln(n+g+d)$	0.434	0.184	0.252	0.298	0.434	0.138	0.119	0.126	0.436
	[10.530]	[5.020]	[5.240]	[6.810]	[10.590]	[3.550]	[2.370]	[2.280]	[9.900]
$ln(A_{ICT})$		0.265	0.051	0.138	0.027	0.314	0.094	0.212	0.120
		[14.860]	[12.660]	[14.290]	[2.150]	[14.420]	[13.840]	[13.190]	[1.920]
CONSTANT	5.191	6.048	6.712	5.981	5.155	6.206	7.544	7.092	5.032
	[17.440]	[24.960]	[17.100]	[15.960]	[17.380]	[25.030]	[17.780]	[15.460]	[15.320]
R^2 (within group)	0.295	0.56	0.623	0.671	0.30	0.552	0.779	0.755	0.198
Obs.	465	465	310	293	465	465	196	181	465
Countries	97	97	74	70	97	97	51	51	97
	In the G2SLS panel estimate $ln(A_{ICT})_t$ is instrumented with $ln(A_{ICT})_{t-2}$, $ln(A_{ICT})_{t-3}$, *and* $ln(A_{ICT})_{t-4}$								

Tab. 3 Growth regressions with and without ICT indicators

DEPENDENT VARIABLE: LOG DIFFERENCE GDP PER WORKING AGE PERSON (1985-1997)							
	(1991-1997)					**(1983-1997)**	
	MRW-TYPE ESTIMATE	EQUATION (1) WITH ICT1	EQUATION (1) WITH ICT3	EQUATION (1) WITH ICT4	EQUATION (1) WITH THE COMPOSITE INDEX	MRW	EQUATION (1) WITH THE COMPOSITE INDEX
$ln(s_k)-ln(n+g+d)$	0.010	0.144	0.009	0.011	0.143	0.407	0.312
	[4.818]**	[3.080] **	[3.437] **	[4.903] **	[3.440] **	[5.140]**	[4.370]**
$ln(s_h)-ln(n+g+d)$	0.002	0.031	0.001	0.001	0.036	0.081	-0.0004
	[2.814] **	[0.930]	[1.146]	[1.089]	[1.280]	[1.510]	[-0.010]
g_{ICT}		0.020	0.030	0.105	0.021		0.124
		[0.790]	[1.955]*	[2.225]**	[1.100]		[5.500]**
$Ln(A_{ICT(1985)})$		0.131	0.060	0.121	0.063		0.102
		[3.040] **	[3.297] **	[4.199] **	[4.590] **		[4.500]
$Ln(Y/L)_{1985}$	-0.038	-0.041	-0.169	-0.240	-0.075	-0.095	-0.227
	[-1.414]	[-1.050]	[-3.399] **	[-4.124] **	[-2.140] **	[-2.140]*	[-4.630]**
CONSTANT	0.170	-0.585	1.409	1.664	-0.171	-1.495	0.783
	[0.857]	[-1.410]	[3.028] **	[3.457] **	[-0.420]	[-4.010]**	[1.330]
R^2	0.311	0.4208	0.520	0.557	0.4549	0.369	0.5346
Test: β=0	0.006	0.363	0.258	0.282	0.272	0.129	
Implied λ						0.024	0.034
Countries	94	88	47	47	94	95	94

** 95 percent significance with bootstrap standard errors, * 90 percent significance with bootstrap standard errors. We use the percentile and bias corrected approach with 2000 replications.

DATA APPENDIX

Variabili ICT		Telephone mainlines (per 1000 people)				Internet hosts (per 10,000 people)				Mobile phones (per 1,000 people)				Personal computers (per 1,000 people)			
id	Country Name	First year		Last year		First year		Last year		First year		Last year		First year		Last year	
1	Algeria	1965	6.0	1997	47.5	1994	0.004	1997	0.011	1990	0.019	1997	0.508	1990	0.996	1997	4.200
2	Angola	1960	1.3	1997	5.3	1994	0.000	1997	0.015	1993	0.107	1997	0.608	1997	0.700	1997	0.700
3	Argentina	1960	44.3	1997	191.0	1994	0.368	1997	5.321	1989	0.072	1997	56.303	1988	4.430	1997	39.216
4	Australia	1960	148.0	1997	505.0	1994	90.037	1997	381.828	1987	0.271	1997	264.324	1988	103.030	1997	362.162
5	Austria	1960	60.8	1997	492.0	1994	34.002	1997	108.283	1985	1.291	1997	143.742	1988	39.474	1997	210.657
6	Bangladesh	1977	0.9	1996	2.6	1994	0.000	1996	0.000	1992	0.002	1995	0.021		#N/D		--
7	Barbados	1960	30.0	1997	404.0	1994	0.000	1997	0.755	1991	1.884	1997	29.888	1995	57.471	1995	57.471
8	Belgium	1960	85.1	1997	468.0	1994	17.250	1997	84.511	1986	0.385	1997	95.490	1988	50.556	1997	235.294
9	Benin	1960	0.9	1997	6.3	1994	0.000	1997	0.022	1995	0.192	1997	0.752	1995	0.547	1997	0.900
10	Bolivia	1980	25.2	1997	68.8	1994	0.000	1997	0.693	1991	0.074	1997	14.929		--		--
11	Botswana	1970	7.3	1997	56.0	1994	0.000	1997	1.553	1995	0.000	1996	0.000	1994	6.993	1996	13.400
12	Brazil	1975	20.3	1997	107.0	1994	0.383	1997	4.196	1990	0.005	1997	27.500	1988	1.786	1997	26.250
13	Burkina Faso	1970	0.2	1997	3.2	1994	0.000	1997	0.046	1995	0.000	1997	0.135	1990	0.113	1997	0.700
14	Burundi	1965	0.4	1997	2.5	1994	0.000	1997	0.012	1993	0.061	1997	0.100		--		--
15	Cameroon	1960	0.5	1997	5.3	1994	0.000	1997	0.054	1994	0.124	1997	0.302	1990	1.304	1995	1.504
16	Canada	1960	278.4	1997	609.0	1994	63.728	1997	227.928	1985	0.463	1997	138.900	1980	4.065	1997	270.627
17	Cape Verde	1960	0.9	1997	81.8	1994	0.000	1997	0.399	1995	0.000	1997	0.049		--		--
18	Central African Republic	1978	1.1	1997	2.8	1994	0.000	1997	0.018	1995	0.013	1997	0.200		--		--
19	Chad	1965	0.4	1997	1.1	1994	0.000	1995	0.000	1995	0.000	1997	0.000		--		--
20	Chile	1960	17.3	1997	180.0	1994	2.181	1997	13.109	1989	0.376	1997	28.082	1988	4.688	1997	54.110
21	China	1975	1.8	1997	55.7	1994	0.005	1997	0.209	1987	0.001	1997	10.476	1988	0.268	1997	5.952
22	Colombia	1960	17.2	1997	148.0	1994	0.327	1997	1.724	1994	2.516	1997	34.807	1992	9.581	1997	33.425
23	Comoros	1970	1.1	1997	8.4	1994	0.000	1995	2.656	1995	0.000	1997	0.000	1970	0.000	1995	0.266
24	Costa Rica	1970	23.1	1997	169.0	1994	2.440	1997	12.295	1992	1.003	1997	18.559		--		--
25	Denmark	1960	182.0	1997	633.0	1994	35.396	1997	259.278	1982	1.406	1997	272.727	1988	58.480	1997	360.200
26	Dominican Republic	1980	19.0	1997	87.5	1994	0.000	1997	0.031	1990	0.442	1997	16.049		--		--
27	Ecuador	1965	9.3	1997	75.2	1994	0.290	1997	0.903	1994	1.598	1997	13.445	1991	1.905	1995	13.043
28	Egypt, Arab Rep.	1960	7.9	1997	55.6	1994	0.027	1997	0.314	1987	0.052	1997	0.116	1994	3.368	1997	7.300
29	El Salvador	1965	4.0	1996	56.1	1994	0.000	1997	0.337	1993	0.302	1997	6.779		--		--
30	Ethiopia	1960	0.3	1997	2.6	1994	0.000	1997	0.000	1995	0.000	1997	0.000		--		--
31	Fiji	1960	13.1	1997	91.9	1994	0.065	1997	0.000	1994	1.438	1997	6.658		--		--
32	Finland	1960	96.6	1997	556.0	1994	133.847	1997	653.631	1982	0.549	1997	417.476	1990	100.000	1997	310.680
33	France	1960	48.0	1997	575.0	1994	14.447	1997	49.840	1986	0.163	1997	99.487	1988	55.258	1997	174.359
34	Ghana	1965	2.2	1997	5.7	1994	0.000	1997	0.153	1992	0.025	1997	1.200	1983	0.000	1997	1.600
35	Greece	1960	21.8	1997	516.0	1994	3.381	1997	18.733	1993	4.615	1997	89.333	1988	12.000	1997	44.762
36	Guatemala	1960	4.4	1997	40.8	1994	0.000	1997	0.839	1990	0.033	1997	6.114	1993	1.047	1995	3.006
37	Guinea	1960	0.6	1997	2.5	1994	0.003	1997	0.003	1993	0.006	1997	0.377	1994	0.054	1997	0.344
38	Guinea-Bissau	1960	0.5	1997	6.8	1994	0.000	1997	0.088	1995	0.000	1997	0.000		--		--
39	Haiti	1981	3.6	1997	8.0	1994	0.000	1997	0.000	1995	0.000	1997	0.000		--		--
40	Honduras	1975	5.6	1997	36.8	1994	0.000	1997	0.986	1995	0.000	1997	2.271		--		--
41	Hong Kong, China	1960	25.7	1997	565.0	1994	20.591	1997	74.839	1984	0.186	1997	343.077	1988	25.688	1997	230.769
42	Hungary	1960	24.3	1997	304.0	1994	6.627	1997	33.302	1990	0.255	1997	69.314	1988	8.286	1997	49.020
43	Iceland	1960	187.5	1997	617.0	1994	169.551	1997	521.481	1986	10.864	1997	241.544	1990	39.063	1995	205.224
44	India	1960	0.7	1997	18.6	1994	0.004	1997	0.050	1995	0.083	1997	0.924	1988	0.185	1997	2.094
45	Indonesia	1960	0.8	1997	24.7	1994	0.009	1997	0.542	1984	0.011	1997	4.557	1988	0.581	1997	7.960
46	Ireland	1960	39.0	1997	411.0	1994	15.281	1997	90.224	1985	0.085	1997	146.027	1990	106.286	1997	241.300
47	Israel	1960	30.6	1997	450.0	1994	22.645	1997	104.764	1990	3.207	1997	282.572	1988	44.346	1997	186.125
48	Italy	1960	60.9	1997	447.0	1994	4.951	1997	36.849	1985	0.112	1997	204.100	1986	9.353	1997	113.043
49	Ivory Coast	1960	0.9	1997	9.3	1994	0.000	1997	0.175	1995	0.000	1997	2.353	1996	1.351	1997	3.268
50	Jamaica	1960	12.2	1996	140.0	1994	0.308	1997	1.366	1991	1.059	1996	21.667	1994	3.457	1996	4.563
51	Japan	1960	38.9	1997	479.0	1994	7.731	1997	75.794	1981	0.113	1997	303.968	1985	17.355	1997	202.381
52	Jordan	1960	13.7	1997	69.7	1994	0.000	1997	0.383	1990	0.338	1995	2.114	1994	5.769	1997	8.700
53	Kenya	1965	2.8	1997	8.1	1994	0.000	1997	0.160	1992	0.044	1997	0.162	1990	0.348	1997	2.300
54	Korea, Rep.	1965	7.7	1997	444.0	1994	4.020	1997	28.782	1986	0.172	1997	150.217	1988	11.190	1997	150.652
55	Luxembourg	1960	116.1	1997	669.0	1994	12.525	1997	91.435	1985	0.109	1997	160.766	1996	375.303	1996	375.303
56	Madagascar	1965	1.5	1997	2.7	1994	0.000	1997	0.029	1994	0.021	1997	0.300	1997	1.300	1997	1.300

DATA APPENDIX(continued)

Variabili ICT		Telephone mainlines (per 1000 people)				Internet hosts (per 10,000 people)				Mobile phones (per 1,000 people)				Personal computers (per 1,000 people)			
id	Country Name	First year		Last year		First year		Last year		First year		Last year		First year		Last year	
57	Malawi	1965	0.9	1997	4.0	1994	0.000	1997	0.000	1995	0.039	1996	0.366		--		--
58	Malaysia	1960	5.8	1997	195.0	1994	0.815	1997	18.707	1986	0.675	1997	113.364	1988	4.142	1997	46.083
59	Mali	1960	0.3	1997	2.0	1994	0.000	1997	0.028	1995	0.000	1997	0.247	1995	0.278	1997	0.600
60	Malta	1960	29.7	1997	498.0	1994	0.000	1997	20.933	1991	6.333	1997	47.074	1990	14.045	1995	80.645
61	Mauritania	1970	0.4	1997	5.4	1994	0.000	1997	0.000	1995	0.000	1997	0.000	1996	5.319	1996	5.319
62	Mauritius	1960	9.1	1997	195.0	1994	0.000	1997	1.838	1990	2.075	1997	32.456	1987	0.456	1997	78.947
63	Mexico	1960	9.7	1997	96.0	1994	0.720	1997	3.735	1988	0.018	1997	18.154	1988	4.469	1997	37.344
64	Morocco	1960	6.7	1997	49.9	1994	0.000	1997	0.325	1987	0.003	1997	2.709	1993	1.149	1997	2.545
65	Mozambique	1960	1.2	1997	3.6	1994	0.000	1997	0.026	1995	0.000	1997	0.137	1996	0.843	1997	1.600
66	Myanmar	1960	0.5	1997	4.6	1994	0.000	1997	0.001	1993	0.015	1997	0.183		--		--
67	Namibia	1981	31.1	1997	58.0	1994	0.000	1997	2.157	1995	2.258	1997	7.764	1996	12.658	1997	18.600
68	Nepal	1975	0.5	1997	7.7	1994	0.000	1997	0.074	1995	0.000	1997	0.000		--		--
69	Netherlands	1960	90.8	1997	564.0	1994	55.807	1997	218.851	1985	0.331	1997	109.554	1988	50.676	1997	280.255
70	New Zealand	1960	225.9	1997	486.0	1994	87.193	1997	413.927	1987	0.738	1997	149.077	1991	96.802	1997	263.852
71	Nicaragua	1970	8.2	1997	29.3	1994	0.114	1997	1.589	1993	0.079	1997	1.818		--		--
72	Niger	1960	0.2	1997	1.6	1994	0.000	1997	0.035	1995	0.000	1997	0.010	1997	0.200	1997	0.200
73	Nigeria	1960	0.4	1996	3.5	1994	0.000	1997	0.001	1993	0.086	1995	0.117	1993	3.810	1997	5.100
74	Norway	1960	126.8	1997	621.0	1994	111.43	1997	474.635	1981	0.407	1997	380.700	1991	145.54	1997	360.800
75	Pakistan	1960	1.3	1997	18.5	1994	0.000	1997	0.075	1990	0.018	1997	0.797	1990	1.339	1996	4.478
76	Panama	1978	59.6	1997	134.0	1994	0.066	1997	1.434	1995	0.000	1997	6.250		--		--
77	Papua New Guinea	1965	1.9	1996	10.6	1994	0.000	1997	0.176	1995	0.000	1996	0.693		--		--
78	Paraguay	1960	4.6	1997	42.8	1994	0.000	1997	0.470	1992	0.332	1997	16.600		--		--
79	Peru	1965	7.2	1997	67.5	1994	0.073	1997	2.671	1990	0.076	1997	17.869	1995	5.957	1997	12.300
80	Philippines	1965	2.5	1997	29.0	1994	0.050	1997	0.586	1991	0.557	1997	17.687	1988	2.058	1997	13.600
81	Poland	1960	18.1	1997	194.0	1994	2.796	1997	11.225	1992	0.057	1997	22.145	1988	3.968	1997	36.176
82	Portugal	1960	11.5	1997	402.0	1994	5.100	1997	18.247	1989	0.284	1997	151.911	1988	14.344	1997	74.447
83	Puerto Rico	1975	81.1	1997	351.0	1994	0.222	1997	0.298	1987	1.153	1996	45.187		--		--
84	Qatar	1960	13.3	1997	249.0	1994	0.000	1997	4.787	1990	7.856	1997	76.450	1994	46.555	1996	62.724
85	Reunion	1970	18.2	1997	351.0	1994	0.000	1997	0.000	1991	4.484	1997	39.673		--		--
86	Romania	1965	16.0	1997	167.0	1994	0.230	1997	2.659	1993	0.035	1997	8.900	1990	0.431	1997	8.900
87	Rwanda	1960	0.4	1996	2.7	1994	0.000	1997	0.008	1995	0.000	1997	0.000		--		--
88	Senegal	1960	2.9	1997	13.2	1994	0.000	1997	0.313	1994	0.012	1997	0.792	1981	0.002	1997	11.400
89	Seychelles	1965	4.9	1996	196.0	1994	0.000	1997	4.508	1995	4.329	1996	15.132		--		--
90	Sierra Leo.	1965	1.1	1997	3.9	1994	0.000	1997	0.000	1995	0.000	1997	0.000		--		--
91	Singapore	1960	22.7	1997	543.0	1994	15.631	1997	195.502	1988	3.789	1997	273.400	1988	42.105	1997	399.500
92	Solomon Islands	1982	6.1	1997	19.3	1994	0.000	1997	0.050	1994	0.393	1997	1.629		--		--
93	Somalia	1960	0.3	1996	1.5	1994	0.000	1995	0.000	1995	0.000	1997	0.000		--		--
94	South Afr.	1960	37.3	1997	107.0	1994	6.693	1997	28.932	1989	0.107	1997	36.951	1988	4.144	1997	41.570
95	Spain	1960	42.1	1997	403.0	1994	7.053	1997	30.980	1986	0.044	1997	110.433	1988	17.857	1997	122.137
96	Sri Lanka	1960	2.3	1997	17.0	1994	0.000	1997	0.329	1990	0.059	1997	6.183	1990	0.176	1997	4.086
97	Sudan	1960	1.5	1997	4.0	1994	0.000	1997	0.001	1995	0.000	1997	0.136	1994	0.195	1997	1.147
98	Suriname	1975	28.8	1997	146.0	1994	0.000	1997	0.000	1993	2.609	1997	9.359		--		--
99	Swaziland	1970	5.9	1996	24.0	1994	0.000	1997	2.504	1995	0.000	1997	0.000		--		--
100	Sweden	1960	279.3	1997	679.0	1994	84.741	1997	321.464	1981	2.452	1997	358.192	1988	59.242	1997	350.282
101	Switzerland	1960	203.4	1997	661.0	1994	67.597	1997	208.843	1987	0.827	1997	146.685	1988	52.317	1997	394.922
102	Syrian A. R.	1960	8.5	1997	87.7	1994	0.000	1997	0.000	1995	0.000	1997	0.000	1994	0.362	1997	1.700
103	Tanzania	1960	0.7	1997	3.3	1994	0.000	1997	0.020	1994	0.013	1997	0.641	1997	1.600	1997	1.600
104	Thailand	1960	1.4	1997	80.0	1994	0.294	1997	2.111	1986	0.016	1997	33.003	1988	1.842	1997	19.802
105	Togo	1960	0.7	1997	5.8	1994	0.000	1997	0.014	1995	0.000	1997	0.694	1995	3.623	1997	5.787
106	Trinidad and Tobago	1965	24.7	1997	190.0	1994	0.000	1997	3.236	1991	0.361	1997	13.594	1991	4.237	1995	20.000
107	Tunisia	1960	6.2	1997	70.1	1994	0.061	1997	0.016	1987	0.030	1997	0.821	1990	2.602	1997	8.574
108	Turkey	1960	6.4	1997	250.0	1994	0.308	1997	3.602	1986	0.007	1997	25.596	1988	2.235	1997	20.668
109	Uganda	1965	1.2	1997	2.4	1994	0.000	1997	0.013	1995	0.091	1997	0.240	1995	0.518	1997	1.400
110	Un. Kingdom	1960	96.1	1997	540.0	1994	38.713	1997	148.834	1985	0.883	1997	151.300	1985	37.102	1997	242.373
111	United States	1960	272.7	1997	644.0	1994	121.80	1997	442.013	1984	0.386	1997	206.343	1981	9.217	1997	406.716
112	Uruguay	1965	52.7	1997	232.0	1994	0.543	1997	3.135	1992	0.546	1997	45.732	1995	21.944	1995	21.944
113	Venezuela	1965	19.5	1997	116.0	1994	0.247	1997	2.054	1988	0.098	1997	46.121	1988	5.435	1997	36.638

114	Yemen, Rep.	1980	2.0	1997	13.3	1994	0.000	1996	0.001	1992	0.124	1996	0.554	1997	1.200	1997	1.200
115	Zambia	1965	4.7	1996	9.4	1994	0.087	1997	0.270	1995	0.165	1996	0.329		--		--
116	Zimbabwe	1975	13.2	1997	17.2	1994	0.017	1997	0.237	1995	0.000	1997	0.900	1990	0.202	1997	9.000