ICT "bottlenecks" and the wealth of nations: a contribution to the empirics of economic growth

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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 labour 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 institutions (Pagano, 1992; King-Levine, 1993) and income inequality (Persson-Tabellini, 1994; Perotti, 1996).

The paradox of this literature, though, is that it has left the labour 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 by implictly assuming that knowledge and its incorporation into productive technology is a public good, freely available to individuals in all countries (Temple, 1999).

This approach does not consider properly the nature of ICT and its role on growth. It neglects the fact that the core of ICT is made by weightless, expansible and infinitely reproducible *knowledge products* (software, databases) which create value in themselves, by increasing productivity of labour or by adding

[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 even akin to proxies adopted in this paper to measure factors crucially affecting ICT diffusion.

value to traditional physical products or traditional services. Knowledge products are almost public goods. Expansibility and infinite reproducibility make then nonrivalrous, and copyright (instead of patent) protection make them much less excludable than other type of innovation such as new drugs (Quah, 1999).

If ICT would consist only of knowledge products, it should therefore be almost immediately available everywhere no matter the country in which it has been created. This does not occur though as 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 iii) the power and availability of terminals which process, implement and exchange knowledge products which flow through the network.

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 and well developed financial markets make it easier to finance projects which aim to implement the capacity of the network and the quality of "terminals".[2]

[2] The relationship between information and communication technology 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 investments (Bender, 1986; Lovemann, 1988; Roach, 1989; Strassmann, 1990). This research showed that there was no statistically significant, or even measurable, association between ICT investments 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 ICT is associated with improvements in productivity, in intermediate measures and in economic growth (Oliner and Sichel, 1994; Brynjolfsson and Hitt, 1996; Sichel, 1997; Lehr-Licthemberg, 1999).

The omitted consideration of "bottlenecks" reducing Information and Communication Technology (from now on BR-ICT), is partially justified so far by the scarcity of data,[3] but has relevant consequences on the accuracy of growth estimates if this variable proves to be significant. First (*omitted variable critique*), if BR-ICT variables proxy for the level of technology are significant and omitted, parameters of the other MRW regressors (labour and investment in physical and human capital) are biased as far as they are correlated with it. Second (*cross-sectional constant critique*), the omitted specification of the labour augmenting technological progress biases regressions on the determinants of levels of per capita income as the difference in technological progress across countries 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.

In addition to reducing most of these problems, the inclusion of BR-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 we show that the introduction of BR-ICT variables, by allowing us to model the unknown country differences in the diffusion of technology, generates a sharp increase in the explanatory power of cross-sectional estimates of

[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 states 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 determinants of levels of income per worker and significantly reduces the effects of the *cross-sectional constant* and *omitted variable* critiques. The increased significance 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 result of the paper (significance of the initial level and the rate of growth of BR-ICT technology in the cross-section and growth regressions) is accurately tested. With boostrap estimates we find that it is not affected by departures from the normality assumption for the distribution of the dependent variable. A sensitivity analysis which follows the Levine-Renelt (1992) approach shows that the introduction of measures of macroeconomic policy performance and of economic, civil and political freedom does not substantially weaken the significance of BR-ICT variables. Generalised 2-Stage Least Squares (G2SLS) panel estimates evidence that the ICT-growth relationship is not affected by endogeneity and exogenous subsample splits demonstrate that our evidence is robust to the issue of parameters heterogeneity.

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 BR-ICT variables on aggregate growth. In the third section we present and comment empirical tests on our hypotheses.

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 "bottlenecks" are a good proxy for measuring the amount technological progress which effectively augments labour productivity in a MRW human capital growth model

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

$$Y_t = F(K, H, AL) = K_t^{a} H^{b} \left(A_t L_t\right)^{1-a-b} \quad \text{with} \quad a + b < 1 \qquad (1)$$

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

Physical capital and human capital follow standard laws of motion.

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

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

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

The growth of the labour input is expressed as:

$$L_t = L_0 e^{nt}. \qquad (4)$$

While in the standard MRW (1992) approach labour augmenting technological progress is exogenous, we make it explicit by assuming that most of it is proxied by weightless, infinitely reproducible, knowledge products (software,databases) which are conveyed to labour through crucial "bottlenecks" represented by the access to the network, the capacity of the network and the availability of "terminals" which process and exchange knowledge products.

We accordingly specify its dynamics as:

$$A_{(t)} = A_{KP(t)} A_{BR\text{-}ICT(t)} \qquad (5)$$

with $A_{BR\text{-}ICT(t)} = A_{BR\text{-}ICT(0)} e^{gBR\text{-}ICT(t)}$ and $A_{KP(t)} = A_{KP(0)} e^{gKP(t)}$

$A_{BR\text{-}ICT}$ is a measure of the stock of ICT factors reducing the above mentioned "bottlenecks" and $g_{BR\text{-}ICT}$ its rate of growth, while $A_{KP(t)}$ is the contribution to technological progress of the stock of

weightless infinitely reproducible knowledge products and g_{KP} is its rate of growth.

We may therefore rewrite the production function in terms of output per efficiency units as $y=k^{?} h^{?}$.

From the model we can obtain the two standard growth equations:

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

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

where $g=g_{BR\text{-}ICT}+g_{KP}$.

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

$$k^* = \left(\frac{s_k^{1-b} \cdot s_h^{b}}{n+g+d} \right)^{\frac{1}{1-a-b}} \quad (8)$$

$$h^* = \left(\frac{s_k^{a} \cdot s_h^{1-a}}{n+g+d} \right)^{\frac{1}{1-a-b}} . \quad (9)$$

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

$$\frac{Y}{L} = Af(k^*, h^*) = Ak^{*a}\ h^{*b} = A_{KP(0)} e^{g_{KP}t} A_{BR-ICT(0)} e^{g_{BR-ICT}t} k^{*a}\ h^{*b} . \quad (10)$$

and:

$$\ln\left(\frac{Y_t}{L_t}\right) = c + \ln\left(A_{BR-ICT(0)}\right) + g_{BR-ICT}\, t + \frac{a}{1-a-b}\ln(s_k) + \frac{b}{1-a-b}\ln(s_h) + -\frac{a+b}{1-a-b}\ln(n+g+d) \quad (10') \text{ or}$$

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

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 measuring respectively the log of the stock of BR-ICT at the initial period and its rate of growth per time units. Therefore, the possibility that all countries have the same steady state level of per capita income depends not only on the levelling of their rate of population growth and of their physical and human capital investment rates, but also on their initial stocks and on their rates of growth of BR-ICT. The model therefore introduces an additional factor of conditionality for convergence in levels. 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[6] (an heroic assumption) but it varies and is crucially influenced by the measured country specific growth rates of BR-ICT technology.

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 $(1-a-b)(n+g)\lambda$ since the solution of the differential equation [7]

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

is :

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

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

[6] This is the approach followed by Solow (1956), Mankiw-Romer-Weil (1992) and Islam (1995) among many others.

[7] This obviously implies that the speed of convergence differs across countries and is crucially influenced by the pace of BR-ICT growth.

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

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

$$\ln(y_t)-\ln(y_0)=(1-e^{-lt})\frac{a}{1-a-b}\ln(s_k)+(1-e^{-lt})\frac{b}{1-a-b}\ln(s_h)+ \\ -(1-e^{-lt})\frac{a+b}{1-a-b}\ln(n+g+d)-(1-e^{-lt})\ln(y_0) \quad (13)$$

or:

$$\ln((Y/L)(t)-\ln((Y/L)(0))=c'+g_{BR-ICT}t+(1-e^{-lt})\frac{a}{1-a-b}\ln(s_k)+(1-e^{-lt})\frac{b}{1-a-b}\ln(s_h)+ \\ -(1-e^{-lt})\frac{a+b}{1-a-b}\ln(n+g+d)-(1-e^{-lt})\ln((Y/L)(0))+(1-e^{-lt})\ln(A_{BR-ICT(0)}) \quad (13')$$

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

The difference with respect to the traditional MRW approach is in the interpretation of the common intercept (which incorporate to us the worldwide diffusion of quasi-public knowledge products) and in the fact that convergence may be prevented by differences in the stock of initial BR-ICT factors or in their rates of growth.

3.1 Empirical analysis: the database and descriptive statistics

Variables for our empirical analysis are taken from the World Bank database.[8] The dependent variable *Y/L* is the gross domestic product per working-age person converted to international dollars using purchasing power parity rates,[9] *L* is

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

[9] An international dollar has the same purchasing power over GDP as the U.S. dollar in the United States.

number of people who could potentially 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 enrollment, 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).[10] To measure factors reducing ICT bottlenecks we consider four different proxies: i) the number of main telephone lines per 1,000 inhabitants;[11] 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).[12]

Tab. 1 provides some descriptive statistics on the above mentioned variables and shows that the dependent variable is not normally distributed when we both consider individual year and overall sample datasets. 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 BR-ICT indicators are far from being a freely available public goods as the variability in the diffusion of BR-ICT across countries is extremely high and persistent (Fig. 1). On average for the entire observation period, it is higher when we consider the latest ICT innovation (the standard deviation of the diffusion of internet hosts across

[10] It is also defined as gross enrollment ratio to compare it with the ratio (net enrollment ratio) in which the denominator is the enrollment ratio only of the age cohort officially corresponding to the given level of education.

[11] 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.

[12] 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. Such information though is not available for long time periods and across the countries observed in oru sample.

countries is two and a half its mean while it is almost equal to its mean in the case of the diffusion of main telephone lines).

Tab A.1 in the Appendix gives the list of countries with sufficient observations which have been selected in the estimates with each of the four BR-ICT proxies. For each country we display the level of the BR-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, while for much less countries and more limited time, if we consider the other three BR-ICT indicators.

For this reason we define a composed indicator which is an unweighted average of each of the four normalised BR-ICT indicators (when available). We then perform our estimates with the composed and with each of the individual BR-ICT indicators.

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

As a first step we regress equation (1) in levels.[13] Our time span is quite limited when we consider a common starting year for individual BR-ICT indicators (1991-97), while it becomes much wider when we use the composite indicator. Tables 2 compares results from the standard MRW model with the model specified in (1) with the different BR-ICT indicators.[14]

[13] We perform the estimate with four different specifications which alternatively consider the ILO labour force and population in working age as labour inputs and 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 that our results be influenced by cyclical effects on output (Temple, 1999). Estimates with the alternative proxies for the labour input and the dependent variable do not differ substantially and are available from the authors upon request.

[14] 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

A first think to be noted is that elasticities of investment in physical and human capital are, as expected, much smaller on such a limited time span (1991-97) also in the traditional MRW estimate, even though both factors significantly affect levels of income per worker. The introduction of starting year levels ($A_{BR\text{-}ICT(0)}$) and rates of growth of BR-ICT variables ($g_{BR\text{-}ICT}$) significantly improves the overall goodness of fit and explains almost 94 percent of the cross-sectional heterogeneity in the specification in which BR-ICT is proxied by the diffusion of personal computers. $A_{BR\text{-}ICT(0)}$ and $g_{BR\text{-}ICT}$ variables are always strongly significant and with the expected sign. On the other hand, the fact that their slopes are smaller than one, the value implicitly assumed by the econometric specification, supports the intuition that ICT is bottleneck reducing. In fact, roughly speaking, one can think of the coefficients of these two variables[15] as the returns of BR-ICT in spreading knowledge. It is, therefore, rather intuitive that widening a bottleneck has decreasing returns as it progressively reduces pressure. The strong significance of the constant term also confirms the hypothesis that BR-ICT factors do not exhaust the contribution of technology to growth and that a common (quasi) public technological factor exists to which (in our opinion) knowledge products contribute. While for the second variable an instrumental variable test is needed to check whether our results are affected by endogeneity (see the generalised 2-stage least square specification explained further), this is certainly not the case for the lagged BR-ICT level ($A_{BR\text{-}ICT(0)}$).

Furthermore, the four regressors included in (10'') are all significant only when we use the composite index, while in almost all other cases the introduction of the BR-ICT variables seems to cast doubts on the significance of the short term

[15] Test on the equalituy of $A_{BR\text{-}ICT}$ and $g_{BR\text{-}ICT}$ coefficients in Tab 2 show that consistently with our hypothesis these coefficients are not significantly different from each other and almost identical in the 1983-1997 sample (respectively 0.302 and 0.299).

elasticity of the investment in physical capital and also on that of human capital when we specify the BR-ICT variable with mobile phones or personal computers.[16] The reestimation of the model with bootstrap standard errors shows that the significance of the BR-ICT variables remains strong for all considered indicators.

A final estimate done by using the composite index on the 1983-1997 time range gives us the idea of 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 BR-ICT is included in the estimate, while s_h is significant and the implied b is *.23*.[17] This number is below the range calculated by MRW for the US.[18] The first result seems to suggest that, a part from the difference in estimation periods, the physical capital contribution falls when we properly consider the role of BR-ICT technological factors (which, in a late sense, are part of physical capital). In the same originary MRW (1992) estimate the physical capital factor share

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and the coefficient of the log of $(n+g+d)$. Estimates in which the assumption is removed do not provide substantially different results and are available from the authors upon request.

[16] 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 (1991), Berndt et al. (1992) and Stiroh (1998).

[17] The lack of 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, while values of s_k are much more equal across subgroups (23.57, 23.18 and 23.00)

[18] 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.

drops to 0.14 in the OECD sample from 0.41 in the overall sample and this change may be consistent with our results given the higher contribution of BR-ICT technology to output in the first group of countries.

Further support for this hypothesis comes from the Jorgenson-Stiroh (1999) empirical paper showing the dramatical 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. Since the decline in computer prices depends on liberalisation and competition on domestic ICT markets it is reasonable to assume that there has been much more substitution between BR-ICT and physical capital in the most advanced OECD countries and therefore that, cross country higher levels and growth rates of income per worker are associated with higher level and growth rates of BR-ICT diffusion, but not necessarily with higher rates of investment in physical capital.[19]

Output elasticities of the two BR-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, but significantly contribute to explain large differences in income per capita which would remain partially unexplained would the role of BR-ICT technology be neglected. The reasonable interpretation for this finding is that part of the contribution of human capital to output

[19] 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 ICT literature finds that, while software investment increases the scale of firm operations, telecommunications investment creates a "flexibility option" easing the switch from a Fordist to a flexible network productive model (Milgrom-Roberts, 1988) in which products and processes are more frequently adapted to satisfy consumers' taste for variety (Brooke, 1991; Barua-Kriebel-Mukhopadhyay, 1991; Paganetto-Becchetti-Londono, 2000).

depends on BR-ICT technology.[20] The former is overstated if the latter is not accounted for.

The use of a cross-sectional regression for estimating the determinants of levels of per capita income has been strongly criticised by Islam (1995). His argument is that, since the labour augmenting A-factor in the aggregate production function represents country specific preferences and technological factors, it is not possible to assume that it is absorbed in the intercept and is therefore constant across countries (*cross-sectional constant critique).* Our estimate overcomes the problem by specifying the technological variable but what if some additional country specific variables (deep fundamentals such as *ethos* or governance parameters such as economic freedom) are omitted ? We have two solutions here: i) a reestimation of (1) as a cross-section with the introduction of variables which may proxy for those omitted; ii) a panel estimate of the same equation in which fixed effects capture all additional country specific variables.[21]

With respect to the first approach we propose a sensitivity analysis in which we subsequently introduce three by three combinations of the following additional explanatory variables: i) average government consumption to GDP; ii) export to GDP; iii) inflation; iv) standard deviation of inflation; v) average rate of government consumption expenditures; vi) average growth rate of domestic credit; vii) standard deviation of domestic credit and, finally, three indexes of economic, civil and legal freedom.[22] All

[20] It is reasonable to figure out, for instance that higher world processing capacity or the possibility of exchanging information in internet increases the productivity of high skilled more than that of low skilled workers.

[21] 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.

[22] The role of inflation on growth is examined, among others by Easterly and Rebelo (1998). For a survey on the role of financial variables on growth see Pagano (1993). The impact of political variables including political freedom has been analysed by Brunetti (1997). The relationship between economic freedom and growth has been investigated, among others, by Dawson (1998) and by Easton-Walker (1997)

these variables, with the exception of indexes of economic, civil and legal freedom are also used by Levine-Renelt (1992) in their sensitivity analysis on the determinants of growth.

Results of sensitivity analysis run on the 1985-1997 period with the BR-ICT composite index 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 (Table 3).[23]

Since the sensitivity analysis emphasizes the strong significance of economic freedom we reestimate the model by adding this variable and by decomposing it into its seven attributes (Table 4). In this way we find that five of the seven attributes are significant (legal structure and property rights, structure of the economy and use of markets, freedom in financial markets, in foreign trade and in exchange markets) while only government size and macroeconomic stability do not directly affect growth in the cross-sectional estimate in levels.

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 5). The ICT significance in fixed effect panel estimates is also robust to the inclusion of any combination of additional regressors (Tab. 6a). Our results are a direct answer to Islam (1995) interpretation of country specific fixed effects in its MRW panel estimate which he finds significantly and positively correlated with growth rates and human capital and interpret as country specific technology effects. Since our BR-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).

[23] The different estimation period with respect to Table 2 is necessary for the reduced availablity of data on civil, legal and economic freedom.

This type of estimate, though, generates an endogeneity problem since the contribution of BR-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 rule out endogeneity problems of estimates in levels we use the G2SLS methodology which combines fixed effect panel estimates with instrumental variables. We use as instruments two period to four period lagged values of BR-ICT indicators and find that BR-ICT variables are still significant (Tables 5-7b).

Results from Table 4 seemed to show that the governance of financial and trade markets was a fundamental factor for growth. The development of financial markets though may even have an impact on the relationship between BR-ICT and growth.[24] Technological innovation and investment in technologies which may reduce ICT bottlenecks (optic fibers, power enhanced mobile phones) is in fact easier to implement in well developed capital markets where it can be equity financed since equity financiers are residual claimants of the expected increase in value generated by the innovation and find it instantaneously incorporated into their share prices. Furthermore, in well developed financial markets, the unobserved quality or power of BR-ICT innovation rate and ICT diffusion is therefore expected to be higher and our BR-ICT proxies (not corrected for quality) to have an increased significance on levels and growth of income per capita.

Exogenous subsample splits help us to investigate whether the BR-ICT - growth relationship is stronger, as we postulated, in countries with more developed financial markets. Consistently with our assumption we find that the significance of

[24] Saint Paul (1992) finds a trade-off between technological diversification (which implies despecialisation and no choice of the more specialised technology) and financial diversification. The development of financial markets allows entrepreneur to achieve diversification on financial market and therefore to reduce technological diversification by choosing the riskier and more profitable technology.

BR-ICT variables is much more pronounced in the OECD and in the higher economic freedom subsample than in their complementary samples (Tab. 7a). Since our index of economic freedom measures at most the development of the banking system (which may proxy but does not coincide with the development of equity markets), we propose an additional indicator based on the stock market capitalisation to GDP. Results from this indicator are consistent with those on the development of the banking system with the BR-ICT factor being more significantly related to income per worker in the high development subgroup in panel fixed effect estimates (Table 7c).

To check whether our results are affected by endogeneity we perform G2SLS panel estimates on these samples. Unfortunately the limited number of degrees of freedom available when we use lagged instruments allows us to estimate the model with sufficient confidence only for the financial freedom split and for the ICT1 and composed index indicators. In these specific cases G2SLS estimates show that, once endogeneity is taken into account, differences between countries with high and low economic freedom persists (tab. 7b).

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 95 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. Tab. 8 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 once we proxy the labour augmenting technological progress with our BR-ICT variables. This suggests that evidence of convergence in the short run can be found only when we consider its conditionality to investment not only in physical capital,[25] but also in BR-ICT. 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). It is also slightly larger when we introduce BR-ICT variables. In interpreting our result of faster convergence we must consider 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 on this result finds that it is confirmed even when we use bootstrap standard errors (and we consider the composite BR-ICT index or the PC diffusion variable) and that it is robust to the inclusion of three by three combinations of all additional variables used in Levine-Renelt (1995) sensitivity analysis plus all different attributes of economic freedom (Tab. 9 and 10).

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

[25] The lack of significance of the coefficient of human capital is a well known result in the literature. Islam (1995) explains it 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 produce positive changes in growth). This is not the case for BR-ICT investment which are shown to have also positive temporal effects in our estimate.

productive factors across the world and significantly increased the productivity of human capital.

ICT 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 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. The wealth of nations therefore crucially depends on the quality of telephone lines, on the number of personal computers, mobile phones and internet hosts as these factors reduce bottlenecks which may limit the diffusion of technological knowledge.

The empirical literature of growth has so far neglected this phenomenon for limits in the available information or under the theoretical assumption that technology is a public good which can be easily and costlessly incorporated into domestic aggregate production functions. Our empirical evidence demonstrates that this is not the case and finds - even though for a limited time span with respect to the traditional empirical analyses on growth - some interesting results which support the theoretical prediction of a significant role of BR-ICT in explaining levels and rates of growth of income per worker. Our results clearly show that the BR-ICT factor is an additional crucial factor of conditionality for convergence in levels and rates of growth and our finding is robust to changes in specification and in the estimation approach.

Table 11 resumes rationales, critical issues and main results of our empirical approaches showing how we rationally moved from the simplest to more sophisticated approaches in order to provide answers to the most important critical issues raised in the empirical literature. Results obtained from the methodological path followed are satisfactory when we look at both level and convergence estimates whose robustness has been tested under several alternative methods.

We may therefore conclude that BR-ICT is another crucial variable which bridges the gap between pessimist views arguing that differences in personal income across countries are a structural element of the economic system which is going to persist and even widen, and optimist views believing that those who lag behind will be able to catch up.

By collecting additional information on ICT diffusion in the next years we will be able to know whether BR-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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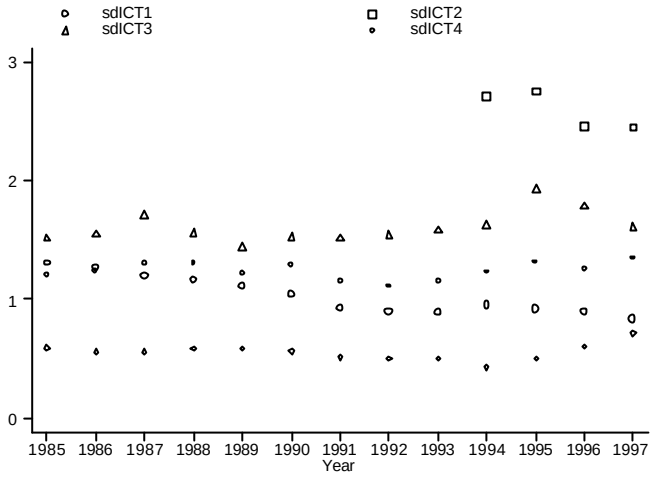
Tab. 1 Shapiro-Wilks normality tests on selected regressors

Years	**1985**		**1986**		**1987**		**1988**		**1989**		**1990**		**1991**	
Variable	**z**	**Prob>z**	**Z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**
gdp	2.720	0.003	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	3.083	0.001	3.106	0.001
ICT1	3.663	0.000	3.713	0.000	3.806	0.000	3.945	0.000	3.992	0.000	4.066	0.000	4.127	0.000
ICT2	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.
ICT3	-0.480	0.684	0.287	0.387	1.280	0.100	1.767	0.039	1.527	0.063	1.888	0.029	2.029	0.021
ICT4	1.288	0.099	1.272	0.102	0.770	0.221	1.876	0.030	2.132	0.017	2.568	0.005	2.689	0.004
ICT	7.366	0.000	7.470	0.000	7.573	0.000	3.768	0.000	3.748	0.000	3.916	0.000	3.792	0.000
S_k - n+g+d	4.419	0.000	3.849	0.000	6.571	0.000	6.178	0.000	5.799	0.000	8.273	0.000	1.379	0.084
S_H- n+g+d	4.098	0.000	4.295	0.000	4.356	0.000	4.333	0.000	4.304	0.000	4.236	0.000	4.273	0.000
Years	**1992**		**1993**		**1994**		**1995**		**1996**		**1997**		**1993-1997**	

Variable	z	Prob>z	z	Prob>z	z	Prob>z	z	Prob>z	z	Prob>z	z	Prob>z	z	Prob>z
gdp	2.988	0.001	3.119	0.001	2.957	0.002	2.974	0.001	3.064	0.001	2.864	0.002	11597	0.000
ICT1	4.163	0.000	4.151	0.000	4.228	0.000	4.337	0.000	4.450	0.000	4.485	0.000	7052.0	0.000
ICT2	no obs.	no obs.	no obs.	no obs.	2.119	0.017	1.503	0.066	1.810	0.035	1.756	0.040	2119.0	0.017
ICT3	1.954	0.025	2.172	0.015	2.467	0.007	3.021	0.001	3.471	0.000	3.446	0.000	5063.0	0.000
ICT4	2.761	0.003	2.748	0.003	2.675	0.004	2.818	0.002	2.835	0.002	2.857	0.002	7426.0	0.000
ICT	3.632	0.000	3.524	0.000	3.346	0.000	3.418	0.000	3.466	0.000	3.469	0.000	6474.0	0.000
S_k - n+g+d	4.519	0.000	3.136	0.001	4.277	0.000	3.046	0.001	3.458	0.000	1.063	0.144	5243.0	0.000
S_H- n+g+d	4.294	0.000	3.801	0.000	3.942	0.000	4.240	0.000	2.711	0.003	5.362	0.000	10233.	0.000

Note: ICT1: main telephone lines per 1.000 people; ICT2: internet hosts (or the number of computers with active Internet Protocol (IP) addresses connected to the Internet) per 10,000 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.

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



Note: sdICT1: standard deviation of main telephone lines per 1.000 people; sdICT2: standard deviation 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 of mobile phones (per 1,000 people). sdICT4: standard deviation of personal computers (per 1,000 people). The last symbol represents sdICT (COMPOSITE INDEX): unweighted average of ICT1, ICT2, ICT3 and ICT4.

Tab. 2 Cross-section regressions with and without BR-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]**
$g_{BR\text{-}ICT}t$		0.240	0.118	0.230	0.174		0.299
		[2.080] *	[3.000] **	[2.220] *	[4.550] **		[8.03] **
$ln(A_{BR\text{-}ICT(0)})$		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 $g_{BR\text{-}ICT}+g_{KP}$, where $g_{BR\text{-}ICT}$ is the growth rate of the selected ICT variable, and g_{KP} is assumed constant across countries. S_h, S_k and $g_{BR\text{-}ICT}t$ 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 boostrap standard errors, * 90 percent significance with boostrap standard errors. We use the percentile and bias corrected approach with 2000 replications.

Tab. 3 Sensitivity analysis on cross-section regressions (1985-1997 estimates with the composite BR-ICT index)

Regressors		Coefficient	T-stat.	R^2	Obs	Additional variables		
	High	0.064	1.290	0.685	74	GOV	EXP	INTSPREAD
$ln(S_k)$-$ln(n+g+d)$	*Base*	0.000	-0.010	0.535	94			
	Low	-0.006	-0.110	0.662	84	EXP	SD_INFL	ECONFREE
	High	0.425	5.860	0.660	74	GOV	INTSPREAD	CIVFREE
$ln(S_h)$-$ln(n+g+d)$	*Base*	0.312	4.370	0.535	94			
	Low	0.254	3.500	0.671	83	EXP	SD_GDC	ECONFREE
	High	0.094	4.060	0.553	91	EXP	GDC	CIVFREE
$ln(A_{BR\text{-}ICT(0)})$	*Base*	0.102	4.500	0.535	94			
	Low	0.070	3.260	0.685	74	GOV	EXP	INTSPREAD
	High	0.115	5.060	0.553	91	EXP	GDC	CIVFREE
$g_{BR\text{-}ICT}t$	*Base*	0.124	5.500	0.535	94			
	Low	0.093	4.220	0.660	74	GOV	INTSPREAD	POLFREE

The sensitivity analysis is run by adding to the benchmark model all three by three combinations of the following variables; GOV: average government consumption to GDP; EXP: export to GDP; INFL: inflation, standard deviation of inflation; GDC: average growth rate of domestic credit; SD_GDC: standard deviation of domestic credit; ECONFREE: economic freedom; CIVFREE: civil freedom; LEGFREE: legal freedom; INTSPREAD: average difference between lending and borrowing rate in the domestic banking system.

In the table we select for each regressor of the base model only the benchmark estimate and the two replications in which the coefficient has the highest and the lowest significance.

Tab. 4 The determinants of levels of income per working age person when indexes of economic freedom are included

Variable	**ECFREE COMPOSITE**	ECFREE (I)	ECFREE (II)	ECFREE (III)	ECFREE (IV)	ECFREE (V)	ECFREE (VI)	ECFREE (VII)
$ln(S_k)$-$ln(n+g+d)$	0.010	0.064	0.073	0.001	0.060	-0.225	0.022	0.111
	[0.080]	[0.450]	[0.530]	[0.010]	[0.460]	[-1.890]*	[0.160]	[0.860]
$ln(S_h)$-$ln(n+g+d)$	0.288	0.269	0.308	0.315	0.314	0.147	0.252	0.294
	[3.480] **	[2.670]	[3.250] **	[3.240]*	[3.510]*	[1.840]*	[2.720]*	[3.370]*
$g_{BR\text{-}ICT}t$	0.219	0.310	0.291	0.311	0.249	0.373	0.246	0.253
	[5.980] **	[8.140] **	[7.600] **	[8.160] **	[6.460] **	[9.290] **	[6.020] **	[6.940] **
$ln(A_{BR\text{-}ICT(0)})$	0.225	0.306	0.285	0.311	0.253	0.354	0.266	0.248
	[6.530] **	[8.390] **	[7.720] **	[8.660] **	[6.950] **	[9.640] **	[7.260] **	[7.060] **
ECFREE	0.217	-0.055	0.065	0.030	0.083	0.109	0.121	0.097
	[5.820] **	[-1.540]	[2.590]*	[1.560]	[4.170] **	[3.540]*	[3.620]	[4.800] **
CONSTANT	5.978	7.613	6.604	7.044	6.345	8.972	6.766	6.172
	[8.050] **	[8.280] **	[7.850] **	[8.350] **	[7.980] **	[12.49] **	[8.470] **	[7.940] **
Countries	86	87	87	87	87	84	87	87
R^2	0.917	0.885	0.891	0.886	0.903	0.929	0.899	0.908

The index of economic freedom published in the *Economic Freedom of the World: 2000 Annual Report* is a weigthed average of the seven following composed indicators designed to identify the consistency of institutional arrangements and policies with economic freedom in seven major areas: ECFREE(I) Size of Government: Consumption, Transfers, and Subsidies [11.0%], i) General Government Consumption Expenditures as a Percent of Total Consumption (50%), ii) Transfers and Subsidies as a Percent of GDP (50%). ECFREE(II) Structure of the Economy and Use of Markets *(Production and allocation via governmental* [14.2%] *and political mandates rather than private enterprises and markets*) i) Government Enterprises and Investment as a Share of the Economy (32.7%); ii) Price Controls: Extent to which Businesses Are Free to Set Their Own Prices (33.5%); iii) Top Marginal Tax Rate *(and income threshold at which it applies*) (25.0%); iv) The Use of Conscripts to Obtain Military Personnel (8.8%). ECFREE(III) Monetary Policy and Price Stability *(Protection of money as a store of value and medium of exchange*)[9.2%], i) Average Annual Growth Rate of the Money Supply during the Last Five Years (34.9%) minus the Growth Rate of Real GDP during the Last Ten Years; ii) Standard Deviation of the Annual Inflation Rate during the Last Five Years (32.6%); iii) Annual Inflation Rate during the Most Recent Year (32.5%). ECFREE(IV) Freedom to Use Alternative Currencies *(Freedom of access to alternative currencies*) [14.6%] i) Freedom of Citizens to Own Foreign Currency Bank Accounts Domestically and Abroad (50%); ii) Difference between the Official Exchange Rate and the Black Market Rate (50%). ECFREE(V): Legal Structure and Property Rights *(Security of property rights and viability of contracts*) [16.6%] i) Legal Security of Private Ownership Rights *(Risk of confiscation*) (34.5%); ii) Viability of Contracts *(Risk of contract repudiation by the government*) (33.9%); iii) Rule of Law: Legal Institutions Supportive of the Principles of Rule of Law (31.7%) and Access to a Nondiscriminatory Judiciary. ECFREE(VI) International Exchange: Freedom to Trade with Foreigners [17.1%] i) Taxes on International Trade, ia Revenue from Taxes on International Trade as a Percent of Exports plus Imports (23.3%), ib Mean Tariff Rate (24.6%), ic Standard Deviation

of Tariff Rates (23.6%), ii) Non-tariff Regulatory Trade Barriers, iib Percent of International Trade Covered by Non-tariff Trade Restraints (19.4%), iic Actual Size of Trade Sector Compared to the Expected Size (9.1%). ECFREE(VII) Freedom of Exchange in Capital and Financial Markets [17.2%], i) Ownership of Banks: Percent of Deposits Held in Privately Owned Banks (27.1%); ii) Extension of Credit: Percent of Credit Extended to Private Sector (21.2%); iii) Interest Rate Controls and Regulations that Lead to Negative Interest Rates (24.7%); iv) Restrictions on the Freedom of Citizens to Engage in Capital Transactions with Foreigners (27.1%).. *Any of the considered freedom indicators has a 0-10 value range. A higher value means a higher level in the item considered by the indicator* .

T-stats are reported in square brackets.
** 95 percent significance with boostrap standard errors, * 90 percent significance with boostrap standard errors. We use the percentile and bias corrected approach with 2000 replications.

Tab. 5 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]
$ln(A_{BR\text{-}ICT})$		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 $ln(A_{BR\text{-}ICT})_t$ is instrumented with $ln(A_{BR\text{-}ICT})_{t-2}$, $ln(A_{BR\text{-}ICT})_{t-3}$, and $ln(A_{BR\text{-}ICT})_{t-4}$								

Tab. 6a Sensitivity analysis on panel regressions (panel fixed effects)

Regressors		Coefficient	T-stat.	R^2	Obs	ADDITIONAL VARIABLES		
	High	0.203	4.770	0.441	317	GOV	EXP	GDC
$ln(S_k)$-$ln(n+g+d)$	*Base*	0.166	6.090	0.304	465			
	Low	0.141	5.300	0.354	460	EXP	INFL	POLFREE
	High	0.515	9.180	0.465	256	GOV	INTSPREAD	CIVFREE
$ln(S_h)$-$ln(n+g+d)$	*Base*	0.434	10.590	0.304	465			
	Low	0.397	9.610	0.367	446	EXP	GDC	POLFREE
	High	0.085	4.270	0.465	256	GOV	INTSPREAD	CIVFREE
$ln(A_{BR\text{-}ICT})$	*Base*	0.027	2.150	0.304	465			
	Low	0.035	2.870	0.354	460	EXP	INFL	CIVFREE

Tab. 6b Sensitivity analysis on panel regressions (G2SLS FIXED EFFECTS**)**

Regressors		Coefficient	T-stat.	R^2	Obs	ADDITIONAL VARIABLES		
	High	0.213	4.740	0.292	339	EXP	INTSPREAD	POLFREE
$ln(S_k)$-$ln(n+g+d)$	*Base*	0.205	5.280	0.198	465			
	Low	0.138	2.110	0.12	328	GOV	INFL	POLFREE
	High	0.473	9.130	0.313	339	EXP	INTSPREAD	CIVFREE
$ln(S_h)$-$ln(n+g+d)$	*Base*	0.436	9.900	0.198	465			
	Low	0.128	0.990	0.12	317	GOV	EXP	GDC
	High	0.389	3.280	0.12	256	GOV	INTSPREAD	POLFREE
$ln(A_{BR\text{-}ICT})$	*Base*	0.120	1.920	0.198	465			
	Low	0.122	2.110	0.263	460	EXP	INFL	POLFREE

The sensitivity analysis is run by adding to the benchmark model all three by three combinations of the following variables: GOV: average government consumption to GDP, EXP: export to GDP, INFL: inflation, standard deviation of inflation, GDC: average growth rate of domestic credit;SD_GDC: standard deviation of domestic credit, ECONFREE: economic freedom, CIVFREE: civil freedom, LEGFREE: legal freedom, INTSPREAD: average difference between lending and borrowing rate in the domestic banking system.

In the table we select for each regressor of the base model only the benchmark estimate and the two replications in which the coefficient has the highest and the lowest significance.

Tab. 7.a Subsample split results on panel regressions

	ICT1			
	PANEL FIXED EFFECTS		G2SLS (FIXED EFFECTS)	
Variable	**OECD**	**NON OECD**	**OECD**	**NON OECD**
$ln(S_k)-ln(n+g+d)$	0.055	0.126	0.055	0.118
	[0.920]	[5.660]	[0.910]	[5.210]
$ln(S_h)-ln(n+g+d)$	0.328	0.067	0.326	0.006
	[5.380]	[1.490]	[5.290]	[0.130]
$ln(A_{BR\text{-}ICT})$	0.400	0.273	0.405	0.324
	[5.840]	[14.850]	[5.710]	[14.100]
CONSTANT	4.851	6.526	4.837	6.789
	[8.410]	[23.840]	[8.360]	[23.720]
Obs	125	340	125	340
Countries	25	72	25	72
R^2 (within groups)	0.559	0.601	0.559	0.590
	ICT COMPOSITE INDEX			
	PANEL FIXED EFFECTS		G2SLS (FIXED EFFECTS)	
Variable	**OECD**	**NON OECD**	**OECD**	**NON OECD**
$ln(S_k)-ln(n+g+d)$	0.026	0.180	-0.182	0.206
	[0.380]	[5.890]	[-1.200]	[4.660]
$ln(S_h)-ln(n+g+d)$	0.427	0.400	0.085	0.414
	[6.400]	[7.550]	[0.420]	[7.260]
$ln(A_{BR\text{-}ICT})$	0.134	0.023	0.741	0.076
	[2.580]	[1.680]	[2.310]	[1.180]
CONSTANT	6.532	5.058	9.708	4.928
	[9.640]	[14.570]	[5.020]	[12.670]
Obs	125	340	125	340
Countries	25	72	25	72
R^2 (within groups)	0.443	0.277	0.157	0.234
	In the G2SLS panel estimate $ln(A_{BR\text{-}CT})_t$ is instrumented with $ln(A_{BR\text{-}ICT})_{t-2}$, $ln(A_{BR\text{-}ICT})_{t-3}$, and $ln(A_{BR\text{-}ICT})_{t-4}$			

Tab. 7.b Financial market freedom, BR-ICT and growth on fixed effect and G2SLS panel regressions

Variable	PANEL FIXED EFFECTS				G2SLS (FIXED EFFECTS)			
	High Financial Freedom	*Low Financial Freedom*	*High Financial Freedom*	*Low Financial Freedom*	*High Financial Freedom*	*Low Financial Freedom*	*High Financial Freedom*	*Low Financial Freedom*
	ICT1		ICT INDEX	COMPOSITE	ICT1		ICT INDEX	COMPOSITE
$ln(S_k)$-$ln(n+g+d)$	0.122	0.093	0.199	0.147	0.110	0.090	0.214	0.148
	[3.170]	[3.490]	[4.020]	[4.050]	[2.810]	[3.350]	[3.970]	[2.800]
$ln(S_h)$-$ln(n+g+d)$	0.229	0.040	0.510	0.326	0.174	0.021	0.476	0.327
	[5.010]	[0.650]	[10.220]	[4.310]	[3.630]	[0.330]	[8.400]	[4.220]
$ln(A_{BR\text{-}ICT})$	0.333	0.253	0.072	0.027	0.394	0.269	0.190	0.029
	[11.990]	[11.330]	[3.350]	[1.410]	[12.600]	[9.640]	[2.900]	[0.280]
CONSTANT	5.566	6.827	4.814	5.549	5.720	6.911	4.963	5.547
	[15.990]	[18.320]	[10.880]	[11.500]	[16.150]	[18.060]	[10.280]	[11.300]
Obs	233	193	233	193	233	193	233	193
Countries	46	41	46	41	46	41	46	41
R^2 (within groups)	0.667	0.567	0.440	0.204	0.658	0.565	0.351	0.204
	In the G2SLS panel estimate $ln(A_{BR\text{-}ICT})_t$ is instrumented with $ln(A_{BR\text{-}ICT})_{t-2}$, $ln(A_{BR\text{-}ICT})_{t-3}$, *and* $ln(A_{BR\text{-}ICT})_{t-4}$							

Note: *high financial freedom*: countries ranked in the highest half according to the ECFREE (VII) indicator described in Table 4. *Low financial freedom*: countries ranked in the lowest half according to the ECFREE (VII) indicator described in Table 4.

Tab. 7.c Equity market development, BR-ICT and income per working-age person

DEPENDENT VARIABLE: LOG GDP PER WORKING AGE PERSON 1997				
Variable	PANEL FIXED EFFECTS			
	High stock market development	*Low stock market development*	*High stock market development*	*Low stock market development*
	ICT1		ICT COMPOSITE INDEX	
$ln(S_k)$-$ln(n+g+d)$	0.071	0.060	0.209	0.087
	[1.440]	[2.120]	[3.810]	[1.930]
$ln(S_h)$-$ln(n+g+d)$	0.249	-0.011	0.334	0.633
	[4.950]	[-0.170]	[5.990]	[8.410]
$ln(A_{BR\text{-}ICT})$	0.336	0.325	0.219	0.031
	[10.860]	[14.030]	[7.540]	[1.510]
CONSTANT	5.738	7.299	6.012	4.209
	[13.470]	[18.640]	[12.000]	[8.200]
Obs	172	166	172	166
Countries	34	35	34	35
R^2 (within groups)	0.654	0.758	0.544	0.396

Note: *high equity market development*: countries ranked in the highest half according to the stock market capitalisation to GDP indicator described in Table4. *Low equity market development*: countries ranked in the lowest half according to the stock market capitalisation to GDP indicator described in Table 4.

Tab. 8 Growth regressions with and without BR-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]
$g_{BR\text{-}ICT}$		0.020	0.030	0.105	0.021		0.124
		[0.790]	[1.955]*	[2.225]**	[1.100]		[5.500]**
$Ln(A_{BR\text{-}ICT(1985)})$		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 boostrap standard errors, * 90 percent significance with boostrap standard errors. We use the percentile and bias corrected approach with 2000 replications.

Tab. 9 Sensitivity analysis on growth regressions (with composite BR-ICT indicator)

DEPENDENT VARIABLE: LOG DIFFERENCE GDP PER WORKING AGE PERSON (1985-1997)								
Regressors		Coefficient	T-stat	R-sq	Obs	Additional variables		
$ln(S_k)-ln(n+g+d)$	*High*	0.425	5.860	0.660	74	GOV	INTSPREAD	CIVFREE
	Base	0.312	4.370	0.535	94			
	Low	0.254	3.500	0.671	83	EXP	SD_GDC	ECONFREE
$ln(S_h)-ln(n+g+d)$	*High*	0.064	1.290	0.685	74	GOV	EXP	INTSPREAD
	Base	0.000	-0.010	0.535	94			
	Low	-0.006	-0.110	0.662	84	EXP	SD_INFL	ECONFREE
$Ln(A_{BR\text{-}ICT(1985)})$	*High*	0.094	4.060	0.553	91	EXP	GDC	CIVFREE
	Base	0.102	4.500	0.535	94			
	Low	0.070	3.260	0.685	74	GOV	EXP	INTSPREAD
$g_{BR\text{-}ICT}$	*High*	0.115	5.060	0.553	91	EXP	GDC	CIVFREE
	Base	0.124	5.500	0.535	94			
	Low	0.093	4.220	0.660	74	GOV	INTSPREAD	POLFREE
$(Y/L)_{1985}$	*High*	-0.206	-4.230	0.685	74	GOV	EXP	INTSPREAD
	Base	-0.227	-4.630	0.535	94			
	Low	-0.314	-6.260	0.670	83	EXP	GDC	ECONFREE

The sensitivity analysis is run by adding to the benchmark model for growth estimated in Table 8 all three by three combinations of the following variables: GOV: average government consumption to GDP, EXP: export to GDP, INFL: inflation, standard deviation of inflation, GDC: average growth rate of domestic credit;SD_GDC: standard deviation of domestic credit, ECONFREE: economic freedom, CIVFREE: civil freedom, LEGFREE: legal freedom, INTSPREAD: average difference between lending and borrowing rate in the domestic banking system.

In the table we select for each regressor of the base model only the benchmark estimate and the two replications in which the coefficient has the highest and the lowest significance.

Tab. 10 Growth regressions with and without BR-ICT and economic freedom indicators (with composite BR-ICT indicator)

	DEPENDENT VARIABLE: LOG DIFFERENCE GDP PER WORKING AGE PERSON (1985-1997)								
Variable	**MRW – type estimate**	ECFREE COMPOSITE	ECFREE (I)	ECFREE (II)	ECFREE (III)	ECFREE (IV)	ECFREE(V)	ECFREE(VI)	ECFREE (VII)
$ln(S_k)$-$ln(n+g+d)$	0.312	0.277	0.331	0.339	0.312	0.317	0.205	0.324	0.332
	[4.370]**	[3.950]**	[4.230]**	[4.640]**	[3.950]**	[4.400]**	[2.420]**	[4.130]**	[4.730]**
$ln(S_h)$-$ln(n+g+d)$	0.000	-0.009	-0.029	-0.026	-0.030	-0.011	-0.068	-0.041	-0.010
	[-0.010]	[-0.170]	[-0.490]	[-0.480]	[-0.520]	[-0.210]	[-1.200]	[-0.700]	[-0.190]
$g_{BR\text{-}ICT}$	0.124	0.107	0.132	0.119	0.129	0.111	0.182	0.127	0.115
	[5.500]**	[4.960]**	[5.610]**	[5.310]**	[5.520]**	[4.980]**	[5.760]**	[5.270]**	[5.360]**
$Ln(A_{BR\text{-}ICT(1985)})$	0.102	0.091	0.109	0.095	0.108	0.093	0.159	0.109	0.093
	[4.500]**	[4.220]**	[4.580]**	[4.150]**	[4.580]**	[4.160]**	[5.200]**	[4.570]**	[4.270]**
$Ln(Y/L_{1985})$	-0.227	-0.304	-0.203	-0.232	-0.217	-0.265	-0.341	-0.234	-0.279
	[-4.630]**	[-6.110]**	[-3.790]**	[-4.750]**	[-4.230]**	[-5.330]**	[-5.380]**	[-4.110]**	[-5.700]**
ECFREE		0.104	0.012	0.041	0.014	0.040	0.046	0.019	0.048
		[4.820]**	[0.640]	[3.320]**	[1.390]	[3.760]**	[2.140]**	[0.930]	[4.370]**
CONSTANT	0.783	1.053	0.568	0.660	0.801	0.883	2.558	0.922	0.895
	[1.330]	[1.940]	[0.830]	[1.150]	[1.320]	[1.570]	[3.230]**	[1.460]	[1.630]*
Countries	94	84	85	85	85	85	82	85	85
R-squared	0.535	0.660	0.567	0.619	0.576	0.632	0.607	0.570	0.651

As BR-ICT indicator we use the composite ICT index wich is an unweighted average of normalised values of the following four ICT variables (when available) i) main telephone lines per 1.000 people; ii) 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). For the definition of the index of economic freedom see Table .

T-stats are reported in square brackets.

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

Tab. 11 Sinthesis of rationales, critical issues and main results of empirical approaches followed in the paper

ESTIMATION APPROACH	MAIN RESULTS WITH ALTERNATIVE SPECIFICATIONS OF THE BR-ICT VARIABLE	CRITICAL ISSUES	POTENTIAL SOLUTIONS
THE DETERMINANTS OF LEVELS OF INCOME PER WORKER (CROSS-SECTION APPROACH)			
Cross-sectional estimate of the determinants of levels of income per worker. The specification of the labour augmenting technological progress overcomes the *cross-sectional constant critique*. (Islam, 1995; Temple, 1999)	Levels and rates of growth of BR-ICT are always significant in any specification. The goodness of fit is higher with BR-ICT variables than in the traditional MRW estimate. In the larger time span with the composite index regressors elasticities are higher as expected.	i) Dependent and explanatory variables are non normal. ii) Additional individual country factors (governance, preferences) are unspecified	i)Estimate with bootstrap standard errors ii)Panel fixed effects or inclusion of additional proxies of country specific effects
Cross-sectional estimate of the determinants of levels of income per worker with bootstrap standard errors	Results are the same as above.	Additional individual country factors (governance, preferences) are unspecified	Panel fixed effects or inclusion of additional proxies of country specific effects
Levine-Renelt (1992) sensitivity analysis in the cross-sectional estimate of the determinants of levels of income per worker with and without bootstrap standard errors	Levels and rates of growth of BR-ICT variables are robust to the inclusion of additional regressors		
THE DETERMINANTS OF LEVELS OF INCOME PER WORKER (PANEL APPROACH)			
Estimation of the determinants of levels of income per worker with panel fixed effect to allow for country specific effects not captured by BR-ICT variables	The BR-ICT variable is significant in any specification	i) Endogeneity problem; ii) Parameters heterogeneity critique (Temple, 1999)	i) G2SLS estimates ii) Estimates for subsample splits
Exogenous subsample split of the estimate of the determinants of levels of income per worker with panel fixed effects	The significance of BR-ICT variables is strong but confined only to OECD, EU and high economic freedom subsamp le while much weaker or not existing	i) Endogeneity problem.	G2SLS estimates

	in their complementary samples (non OECD, non UE, low economic freedom)		
G2SLS estimates to avoid endogeneity	BR-ICT variables are still significant.		
CONVERGENCE			
Cross-sectional estimate of the determinants of rates of growth in income per worker. The high fit of the cross-sectional estimate in levels partially overcomes the cross-country heterogeneity critique	Initial period levels and rates of growth of BR-ICT are positive and significant.	Dependent and explanatory variables are non normal. Unexplained cross-country hetereogeneity critique may generate correlation between the lagged dependent variable and the disturbance	
Cross-sectional estimate of the determinants of rates of growth in income per worker with bootstrap standard errors	Initial period levels and rates of growth of BR-ICT are positive and significant.	cross-country heterogeneity critique still partially unsolved and additional individual country factors are unspecified. Potential solutions: a) panel fixed effect estimate or b) sensitivity analysis with the inclusion of additional proxies for country specific effects	
Levine-Renelt (1992) sensitivity analysis on growth estimates	Initial period levels and rates of growth of BR-ICT are positive and significant.		

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		#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		#N/D		#N/D
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		#N/D		#N/D
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		#N/D		#N/D
18	Central African Republic	1978	1.1	1997	2.8	1994	0.000	1997	0.018	1995	0.013	1997	0.200		#N/D		#N/D
19	Chad	1965	0.4	1997	1.1	1994	0.000	1995	0.000	1995	0.000	1997	0.000		#N/D		#N/D
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		#N/D		#N/D
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		#N/D		#N/D
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		#N/D		#N/D
30	Ethiopia	1960	0.3	1997	2.6	1994	0.000	1997	0.000	1995	0.000	1997	0.000		#N/D		#N/D
31	Fiji	1960	13.1	1997	91.9	1994	0.065	1997	0.000	1994	1.438	1997	6.658		#N/D		#N/D
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		#N/D		#N/D
39	Haiti	1981	3.6	1997	8.0	1994	0.000	1997	0.000	1995	0.000	1997	0.000		#N/D		#N/D
40	Honduras	1975	5.6	1997	36.8	1994	0.000	1997	0.986	1995	0.000	1997	2.271		#N/D		#N/D
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
57	Malawi	1965	0.9	1997	4.0	1994	0.000	1997	0.000	1995	0.039	1996	0.366		#N/D		#N/D
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		#N/D		#N/D

DATA APPENDIX(continued)

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		#N/D		#N/D
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		#N/D		#N/D
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	111.438	1997	474.635	1981	0.407	1997	380.700	1991	145.540	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		#N/D		#N/D
77	Papua New Guinea	1965	1.9	1996	10.6	1994	0.000	1997	0.176	1995	0.000	1996	0.693		#N/D		#N/D
78	Paraguay	1960	4.6	1997	42.8	1994	0.000	1997	0.470	1992	0.332	1997	16.600		#N/D		#N/D

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		#N/D		#N/D
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		#N/D		#N/D
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		#N/D		#N/D
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		#N/D		#N/D
90	Sierra Leone	1965	1.1	1997	3.9	1994	0.000	1997	0.000	1995	0.000	1997	0.000		#N/D		#N/D
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		#N/D		#N/D
93	Somalia	1960	0.3	1996	1.5	1994	0.000	1995	0.000	1995	0.000	1997	0.000		#N/D		#N/D
94	South Africa	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		#N/D		#N/D
99	Swaziland	1970	5.9	1996	24.0	1994	0.000	1997	2.504	1995	0.000	1997	0.000		#N/D		#N/D
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 Arab Republic	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	United 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	121.807	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		#N/D		#N/D
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