STUDIECENTRUM VOOR ECONOMISCH EN SOCIAAL ONDERZOEK

VAKGROEP PUBLIEKE ECONOMIE

An Assessment of the Macroeconomic Determinants of Inequality

Patrick Vanhoudt*

Report 97/347

Juni 1997

* Belgian Fund of Scientific Research and University of Antwerp (FWO and UFSIA, Belgium). I would like to thank Martin Fetherston, Tim Lane, Ramana Ramaswamy and Bart Turtelboom (all IMF, Washington DC), Walter Nonneman (UFSIA), Walter Van Trier (UFSIA) and Matthew Tharakan (UFSIA and University of Louvain, Belgium) for useful comments and suggestions on an earlier draft of this paper, as well as the members of the electronic discussion list on economic growth (majordomo@alpha.ufsia.ac.be). As a Fulbright Scholar I am also grateful to the Commission for Educational Exchange. This paper was started while I was visiting the UC at Berkeley. All errors are of course mine.

Universitaire Faculteiten St.-Ignatius
Prinsstraat 13 - B 2000 Antwerpen
D/1997/1169/007

Abstract

This paper provides an assessment of the determinants of income inequality in a broader macroeconomic context. In particular the hypothesis that income inequality is related to fundamentals affecting economic growth is examined. It shows that a modified Kuznets model in which economic growth is generated by an augmented Solow model provides an excellent description of the cross-country data on variation in the level, but more importantly, the trend rates in gini coefficients of household income. The paper also examines the implications for convergence in inequality, that is, for whether initially more unequal economies tend to have larger changes in inequality than initially more equal economies. The evidence indicates that countries evolve at about the speed predicted by the model.

JEL Classification Code:

D30, E62, H30, O40

An Assessment of the Macroeconomic Determinants of Inequality.

I. Introduction

Why do different countries have such different levels of, and trend rates in inequality? This paper takes Simon Kuznets seriously. In his classic 1955 paper Kuznets advanced the theoretical conjecture that a nation's income distribution becomes less, rather than more, egalitarian as its income level increases. Only after a nation has passed some threshold level, growth brings about more equality. In other words Kuznets' hypothesis states that the evolution of income distribution follows an inverted U-shaped curve: economic expansion results in relatively more inequality in the initial stages of a nation's development, and relatively more equality at advanced stages. Kuznets' hypothesis was based on the theories of economic growth prevalent in the fifties together with empirical observation. Those theories explained growth as a process of shifts of the working force from the traditional rural to a more productive industrial sector. The empirical observation was that the relative difference in per capita income between the rural and urban populations did not necessary drift downward in the process of economic growth. Under these assumptions, Kuznets conjectured, the development of a typical country was likely to be coupled with both higher per capita incomes and greater income inequality, as it meant that over time an increasingly higher fraction of the population would be located in the more productive, but more unequal, industrial sector.

One would thus expect a negative relation between inequality and per capita income for a sample of developed countries and the opposite for developing countries - other things being constant. Empirical support for the latter hypothesis, however, is rather poor. For instance, in table I estimation results are reported of regressions à la Kuznets for a sample of 21 developed countries in 1975 and 1989 and for a sample of 22 developing countries over the time span 1975-1988 (a description of the data follows later).

Table I: Kuznets conjecture.
Dep. Var. is ln(gini)

	Developed countries		Developing countries
Variable	**Estimations for 1975**	**Estimations for 1989**	**Estimations for 1975-1988 (GDP/W=1985)**
constant	1.722 (0.949)$^{+}$	-0.700 (0.759)	-1.547 (0.291)$^{++}$
ln(GDP/worker)	-0.292 (0.100)$^{++}$	-0.035 (0.075)	0.089 (0.037)$^{++}$
R^2	30.04 %	1.03 %	20.54 %
adj. R^2	26.15 %	0.00 %	16.57 %
ser	0.161	0.146	0.102
Sample	21 developed countries	21 developed countries	22 developing countries

$^{+}$: significant at the 10% level, $^{++}$: significant at the 5% level or better.

Although Kuznets conjecture seems to be confirmed in these simple basic Kuznets regressions avant la lettre - indeed the sign of the coefficient on per capita income is negative for developed countries and positive for developing countries- the estimations are not robust and the explanatory power is poor: at most one third. These findings are certainly not new: it is well known that empirical evidence supporting the Kuznets curve turns out to be inconclusive (see e.g. Adelman and Robinson [1989] or Anand and Kanbur [1993] for a review).

Hence not everything is all right with Kuznets theory. In particular we find the fact that economic growth is kept exogenous, not explained by the model, bothersome. Recent studies in economic growth provide theoretical and empirical support for the fact that both the level and the growth rate of income per worker are determined by economic fundamentals (see e.g. Romer [1990], Rebelo [1991], Levine and Renelt [1992] or Mankiw, Romer and Weil [1992] amongst many others). These fundamentals have been proven to have different impacts on economies' long-run performance. It therefore might well be the case that two countries are observed which reached a similar level of per capita income, but by focusing on different fundamentals. If those fundamentals have different consequences for the distribution of the additional income generated by the growth process, the poor explanatory power of regressions as reported in table I is not surprisingly, for important control variables have been omitted. In this paper we advance the hypothesis that growth related fundamentals may be correlated with the observed differences in inequality. In other words, after controlling for factors which influence a country's steady state and economic growth one might come to the conclusion that there is a significant relation between per capita GDP and the level of inequality in the Kuznets sense.

Theoretical attempts to go beyond Kuznets theory have recently been put forward by several authors. For instance Galor and Tsiddon [1996] developed an OLG model in which an endogenous mechanism with spill-overs on the human capital side generates the inverted U-shaped Kuznets curve over time. Theoretical ways of generating persistent differences in income are analyzed in Aghion and Bolton [1996]. In their story capital market imperfections that result from the difficulty in insuring against future income uncertainty are the basis of inequality. Yet empirical tests of these theories have remained out.

The continuous time model presented in section II of this paper is much more simple. In contrast to Galor and Tsiddon [1996] there are no spill-overs whatsoever, and in contrast to Aghion and Bolton there are no market imperfections. The production factors in this model are physical capital and (technological) knowledge for which property rights are assumed complete. Therefore a well functioning market for both types of capital exists. Hence the neoclassical assumptions hold and an augmented Solow growth model can be applied. In section III will be focused on the model's implications for cross-country data on trend and level of gini coefficients. Persson and Tabellini [1994] recently asked the question whether inequality is harmful for growth. They reported it is. This paper's question is rather: is growth harmful for inequality?. We find that the dynamic process of economic growth drives countries to their steady state level of inequality at a rate predicted by the model, which implies that initial relatively equal countries will experience a widening in the income distribution while the opposite holds for initial relatively more unequal countries. Section IV summarizes and concludes.

II. An Extended Kuznets Model

Given that economic growth in Kuznets original theory is exogenous, it seems appropriate to go beyond his framework and propose and analyze here a model for the process of economic growth in detail before turning to the point of inequality.

Following Kuznets [1955] there are two types of labor, and two sectors in the economy. In the present version , however, there will not be such thing as rural and urban labor. We will rather focus on high skilled (L_s) and relatively unskilled (L_u) labor, physical capital (K) and (technological) knowledge (W) as factors of production, and a goods producing and educational sector. Both stocks of capital are held by skilled labor. Skilled labor is different from unskilled in the sense that it has been trained and carries "technological knowledge". Only skilled labor is employed. Unskilled labor receives an unemployment benefit which is paid out of a lump sum tax. It is the unemployment feature which allows for persistent differences in income in this approach. Further, the total effective work force (AN) grows at an exogenous rate which equals the sum of the growth rate of the labor force and technology (n+x). Production takes place according to the following Cobb-Douglas production function:

$$(1) \qquad Y = A \cdot K^{\alpha} \cdot W^{(1-\alpha)}.$$

Technological knowledge (W) evolves over time because every period new students go to college. In these institutions they use their human capital to become skilled labor units via the exposition to, and training in the working of technology. Inputs to this educational sector thus are threefold: the available human capital (H), exogenously growing technology (A), and newly born workers which are in this framework useful only as something to be educated, not as a direct input to the production of final goods. However, a fraction ($1-a_n$) of the newly borns drops out and refuses to become high skilled for whatever reason. The law of motion for knowledge then is[1]

[1] A dot above a variable denotes a time derivative

(2) $$\dot{W} = A \cdot H^{\varphi} \cdot \left[a_n \cdot \left(A \dot{\cdot} N \right) \right]^{1-\varphi}.$$

The progress of knowledge is thus determined by the stock of human capital which, in turn, is accumulated by investing a fraction of total output, s_h[2] in "general education":

(3) $$\dot{H} = s_h \cdot Y$$

Following equation (2) skilled and unskilled labor accordingly evolve over time as:

(4) $$\dot{L_s} = a_n \cdot (A \dot{\cdot} N) \quad \text{and} \quad \dot{L_u} = (1 - a_n) \cdot (A \dot{\cdot} N)$$

Unskilled labor becomes unemployed and receives a benefit $\overline{w} < w_s$ per unit which is financed by a lump sum tax τ levied by the government. She redistributes these taxes with an efficiency ε to the unemployed.

(5) $$\frac{[\tau]^{\varepsilon} \cdot AN}{L_u} = \overline{w} \qquad \text{with} \quad -\infty < \varepsilon \leq 1.$$

Finally, de law of motion for the capital stock is standard:

(6) $$\dot{K} = s_k \cdot Y.$$

Defining y as output per capita, y=Y/(AN), k as the stock of physical and h the stock of human capital per capita, k=K/(AN) h=H/(AN), w as the stock of knowledge per capita (w=W/(AN),and l_s and l_u as the share of skilled and unskilled labor in the effective work force, $l_{u,h}=L_{u,h}/(AN)$, the system that governs the accumulation of w, k, h, l_s and l_u becomes:

---

[2] Depreciation of capital of any form is ignored throughout the paper

$$(7)\qquad \begin{aligned} \frac{\dot{w}}{w} &= A\cdot\frac{h^{\varphi}}{w}\cdot\left[a_n\cdot(n+x)\right]^{1-\varphi}-(n+x) \\ \frac{\dot{k}}{k} &= A\cdot s_k\cdot k^{-(1-\alpha)}\cdot w^{1-\alpha}-(n+x) \\ \frac{\dot{h}}{h} &= A\cdot s_h\cdot k^{\alpha}\cdot\frac{w^{1-\alpha}}{h}-(n+x) \\ \frac{\dot{l}_s}{l_s} &= a_n\cdot\frac{(n+x)}{l_u}-(n+x) \quad ; \quad \frac{\dot{l}_u}{l_u}=(1-a_n)\cdot\frac{(n+x)}{l_u}-(n+x) \end{aligned}$$

The first three equations of (7) basically determine the dynamics of the economy's per capita income. We will assume there exists a balanced growth path on which all per capita variables grow at a zero rate. The loci for which w, h and k are constant then are:

$$(8)\qquad \begin{aligned} w_* &= A\cdot h_*^{\varphi}\cdot a_n^{1-\varphi}\cdot(n+x)^{-\varphi} \\ k_* &= A^{\frac{1}{1-\alpha}}\cdot s_k^{\frac{1}{1-\alpha}}\cdot w_*\cdot(n+x)^{-\frac{1}{1-\alpha}}. \\ h_* &= A\cdot s_h\cdot k_*^{\alpha}\cdot w_*^{1-\alpha}\cdot(n+x)^{-1} \end{aligned}$$

Jointly they determine a unique and stable steady state[3] (E) in the [w, k] space, as can be seen from chart 1. Solving the above system (8) yields reduced form expressions for w_*, k_*, and h_* which are solely functions of the underlying economic fundamentals:

[3] We ignore the possibility of a starting position where k=0 or w=0. If the initial value for k *or* w is 0, the economy converges to k=h=0

$$\ln(w_*)=\frac{1-\alpha(1-\varphi)}{(1-\alpha)(1-\varphi)}\cdot\ln(A)+\frac{\varphi}{1-\varphi}\cdot\ln(s_h)+\frac{\alpha\varphi}{(1-\alpha)(1-\varphi)}\cdot\ln(s_k)+\ln(a_n)$$
$$-\frac{\varphi(2-\alpha)}{(1-\alpha)(1-\varphi)}\cdot\ln(n+x)$$

(9)
$$\ln(k_*)=\frac{1+(1-\alpha)(1-\varphi)}{(1-\alpha)(1-\varphi)}\cdot\ln(A)+\frac{\varphi}{1-\varphi}\cdot\ln(s_h)+\frac{1-\varphi(1-\alpha)}{(1-\alpha)(1-\varphi)}\cdot\ln(s_k)+\ln(a_n)$$
$$-\frac{1+\varphi(1-\alpha)}{(1-\alpha)(1-\varphi)}\cdot\ln(n+x)$$

$$\ln(h_*)=\frac{1}{(1-\varphi)(1-\alpha)}\cdot\ln(A)+\frac{1}{1-\varphi}\cdot\ln(s_h)+\frac{\alpha}{(1-\alpha)(1-\varphi)}\cdot\ln(s_k)+\ln(a_n)$$
$$-\frac{1+\varphi(1-\alpha)}{(1-\alpha)(1-\varphi)}\cdot\ln(n+x)$$

with the implied steady state expression for per capita income:

$$\ln(y_*)=\frac{1+(1-\alpha)(1-\varphi)}{(1-\alpha)(1-\varphi)}\ln(A)+\frac{\varphi}{(1-\varphi)}\ln(s_h)+\frac{\alpha}{(1-\alpha)(1-\varphi)}\ln(s_k)$$
$$-\frac{2\varphi(1-\alpha)+\alpha}{(1-\alpha)(1-\varphi)}\ln(n+x)+\ln(a_n)$$

Now let us take a look at inequality in this simple economy. Inequality (IE) is defined here as an exponential function of the top-to-bottom ratio, viz. the ratio of the income share (before taxes) in GDP held by skilled workers to the income share in GDP held by the unskilled (unemployed) persons. Since all factors of production earn their marginal product, it is henceforth easy to verify that the level of inequality at any point in time equals:

(10)
$$IE=\left[\frac{w_s\cdot L_s}{\bar{w}\cdot L_u}\right]^{\lambda}=\left[\frac{\frac{\partial Y}{\partial W}\cdot\frac{W}{L_s}\cdot L_s}{\bar{w}\cdot L_u}\right]^{\lambda}=\left[(1-\alpha)\cdot y\cdot\tau^{-\varepsilon}\right]^{\lambda}.$$

The relation between the level of development and inequality is - as in Kuznets theory - clearly present in this model. Obviously $\lambda<0$ in a sample of developed countries and $\lambda>0$ in a sample of developing countries would support Kuznets conjecture. Yet y evolves over time - and thus so will inequality - due to changes in k, w and h until the economy reaches its steady state. Since both k and w have different impacts on the growth process, this all implies that different policies with regard to accumulating capital (broadly interpreted) for generating growth may have different impacts on the distribution of income.

The effect of changes in policy variables on the dynamics of inequality is best analyzed starting off from an economy which is initially on its balanced growth path. Suppose there is an increase in the savings rate (or another parameter which only shifts the 0-locus for k upwards). The economy will start growing towards its new steady state. During the transition both w and k will increase as depicted in chart 2. The new equilibrium income per worker is higher than the old one. If Kuznets conjecture holds in the sample of developed countries ($\lambda<0$), the level of inequality will be lower in the new steady state. Shifts in the 0-locus for w (due to e.g. increase in the investment share in education, reduction in unemployment, etc.) result in similar dynamics. Note that increases in population growth or in the growth rate of technology affect both curves at the same time, resulting in a declining GDP per capita and rising inequality. For a sample of developing countries with $\lambda>0$ the opposite conclusions must hold.

The central prediction of this model, however, concerns the impact of economic fundamentals such as the propensity to save, population growth, the share of skilled labor in total workforce and taxes on inequality. Substituting (9) in (10) after having taken logs, we find that the steady state level of inequality is:

$$
\begin{aligned}
(11)\qquad \ln(IE_*) &= \ln(1-\alpha)^{\lambda} + \frac{\lambda[1+(1-\alpha)(1-\varphi)]}{(1-\alpha)(1-\varphi)}\ln(A) + \frac{\alpha\lambda}{(1-\alpha)(1-\varphi)}\ln(s_k) \\
&\quad + \frac{\varphi\lambda}{1-\varphi}\ln(s_h) + \lambda\ln(a_n) - \frac{\lambda[\alpha+2\varphi(1-\alpha)]}{(1-\alpha)(1-\varphi)}\ln(n+x) - \lambda\varepsilon\ln(\tau)
\end{aligned}
$$

Because the model assumes that skilled labor and physical capital are paid their marginal product, it predicts not only the signs but also the magnitudes of the coefficients. Especially, since the share of human and physical capital in total income is roughly one third (see e.g. Mankiw, Romer and Weil [1992]), the model implies an elasticity of inequality with respect to the investment share in physical capital of about 0.75λ, an elasticity of about 0.50λ with respect to the investment share in human capital (their ratio thus should be around 1.5) and an elasticity of around -1.75λ with respect to population growth (the ratio between the elasticities of inequality w.r.t. physical capital and population growth thus should be around -0.43).

III. Empirical testing

A. Specification

The natural question to consider is whether the data support this modified Kuznets model's prediction concerning the determinants of inequality in a broader macroeconomic context. For developed countries λ is presumably negative, and thus we want to investigate whether inequality is lower in countries with higher investment shares in both physical and human capital, higher population growth, and higher taxes. The opposite results should show up for developing countries with λ presumably positive. Moreover we are curious whether this model improves the fit of the data compared with the textbook Kuznets regression from table I.

We assume that x is constant across countries. This variable primarily reflects the advancement in technology which is available as a public good. The rate of technological progress will henceforth be approximately the same, or at least there is no indication to assume differently. However, resource endowments, institutions, people's temper and speed of learning, their willingness to work and so forth, which is captured in the initial condition of the technology variable A, may substantially influence the evolution of inequality. $Ln(A)=ln(A_0)+xt$ thus may be country specific. We assume therefore that $ln(A)=a+u$ in which a is a constant and u is a country specific shock. Thus, the log of inequality at a given time is:

$$(12) \quad \ln(IE_*) = c_0 - c_1 \ln(s_k) - c_2 \ln(s_h) - c_3 \ln(a_n) + c_4 \ln(n+x) + c_5 \ln(\tau) + \sigma_i$$

$$\text{with } \sigma_i = \frac{\lambda[1+(1-\alpha)(1-\varphi)]}{(1-\alpha)(1-\varphi)} u_i$$

We further assume that the right-hand side variables are independent of u_i. In order to take into account the possibility of heteroscedasticity, equation (12) will be estimated by means of the iterative weighted least squares procedure. It will be estimated as such, but also under the restriction that the coefficient on ln(n+x) should equal minus the coefficient on $\ln(s_k)$ minus two times the coefficient on $\ln(s_h)$.

In addition this model makes the prediction that countries will converge to *their* steady-state level of inequality at a certain speed. Let IE_* be the steady state level of inequality given by equation (12), and let IE_t be the actual level of inequality. Approximating the growth rate of IE_t by a log-linearization around the steady state, the model implies the following regression to study the rate of convergence β (β≥0)

$$(13) \quad \ln(\frac{IE_t}{IE_0}) = (1-e^{-\beta \cdot t}) \cdot [\ln(IE_*) - \ln(IE_0)].$$

In which $\ln(IE_*)$ can be replaced by equation (11). More specifically, the speed of convergence (β) is either[4] $\beta = -1/2 \cdot (n+x) \cdot \left[2-\alpha \pm \sqrt{\alpha^2 + 4 \cdot \varphi(1-\alpha)}\right]$ or -(n+x).

Using again one third for α, 5 percent as a reasonable guess for x, and 1 percent for the growth rate of the working population, we expect countries to converge towards *their* steady state of inequality at about a speed of roughly 2, 6 or 8 percent p.a.

By consequence the empirical specification to test for convergence is:

$$(14) \quad \ln(\frac{IE_t}{IE_0}) = d_0 + d_1 \ln(s_k) + d_2 \ln(s_h) + d_3 \ln(a_n) - d_4 \ln(n+x) - d_5 \ln(\tau) - d_6 \ln(IE_0) + e_i$$

---

[4] Due to the non-linear system of difference equations in (7) we cannot rule out any of the speeds on a theoretical base. See appendix II for mathematical details.

Thus, in the modified Kuznets model changes in inequality are a function of the determinants of the ultimate steady state and the initial level of inequality. This equation will again be estimated with the iterative weighted least square procedure.

Note that equation (11) is valid only if countries are in their long-run equilibrium, or if deviations from this equilibrium are random. Equation (13) has the advantage of explicitly taking into account out-of-steady-state dynamics. Another advantage of equation (13) is that the dependent variable consists of trend rates in inequality. Comparing absolute levels of inequality indicators across countries is often criticized because of possible measurement errors. Indeed, differences in e.g. the questionnaires used to obtain information on household income data certainly exist. However, estimations for, and comparisons of trend rates will be unbiased as long as the measurement error for each country remains consistent over time.

B. Data

The data are from various sources. For the 21 developed countries the gini coefficients are taken from Deininger and Squire's new database on inequality [1994]. We used the gini of the household income distribution, measured as closely as possible to 1975 and 1989. Based on those two observations an annual average growth rate was computed with which the gini coefficients were re-adjusted to 1975 and 1989[5]. Unfortunately less detailed data are available for developing countries. The UNDP reports average gini coefficients for some developing countries over the time span 1975-1985. Henceforth the dynamic regression cannot be tested for this sample. The sample of developing countries consists of 22 observations. Average investment shares in physical capital (s_k) for the time span 1975-1989 are taken from the Penn World Table mark 5.6. As for the average investment share in education (s_h) we borrowed Barro's and Lee's data on government expenditures on education. Averages were taken for 1975-1985. The growth rates of the working population (n) are computed from the same source. The Barro and Lee database also provided the data on a_n for which we considered the percentage in total population which has completed higher education, on average over

[5] We opted for 1989 as the endpoint because this required the least number of adjustments.

the span 1975-1985. Finally, data on the per capita levied direct taxes (average percentage of GDP times GDP per capita) are taken from the OECD Economic Outlook and the UNDP reports. Data are in appendix I.

C. Results

We estimate equations (12) and (14) - both restricted and unrestricted - in which we assume that x is 5 percent; reasonable changes in this assumption have little effect on the estimates. Table II reports the results.

Let us consider the regressions for the developed countries. Four aspects of the results for this sample support the extended Kuznets model. First, the coefficients on the traditional growth fundamentals have the predicted signs (opposite to the ones observed in growth regressions - indicating a negative value for Kuznets coefficient) and are significant at the traditional confidence levels. Second, the magnitudes of the estimates on the fundamentals seems to be very much compatible with the theory. The ratio between the coefficients on investment physical and human capital is 1.2 (1.3 for restricted regression) which is somewhat low, but a Wald test did not reject the null hypothesis that the ratio is statistically different from its theoretical predicted value of 1.5. Neither did Wald tests reject the null hypothesis that the ratio of the coefficients on $\ln(s_k)$ to $\ln(n+x)$, and the ratio of $\ln(s_h)$ to $\ln(n+x)$ are at their theoretical predicted value of -0.4286 (-0.75/1.75) and -0.2857 (-0.5/1.75) respectively. Fixing α at one third yields an acceptable share of human capital of around 0.3[6].

Third, the speed of convergence is statistically not different from the predicted 6 per cent p.a.. This implies that economies move halfway to their steady state level of inequality in about twelve years, eighty percent of the gap would be bridged in about twenty seven years. Looking for instance at the UK, where inequality has been increasing since the early eighties, this would mean that the steady state level of inequality will be reached around the first decade of the next century. Fourth, the model explains about sixty percent of the variation in the inequality levels, and up to two thirds of the variation in the trend rates of inequality in a sample of developed countries, while the Kuznets coefficient is significantly negative (about -0.45 in the steady state, somewhat lower (about -0.35) in the dynamic regressions).

[6] One can compute φ and λ from the coefficients on $\ln(s_k)(=c_2)$ and $\ln(s_h)(=c_3)$. From the theoretical ratio of both coefficients it follows that $\varphi=\alpha.c_2/c_1$. Substituting this into the expression for the theoretical coefficient on $\ln(s_k)$ yields $\lambda=(c_1/\alpha).(1-\alpha).(1-\alpha.c_2/c_1)$

Table II: Estimation Results for the Modified Kuznets Model

	Developed countries				Developing countries	
VARIABLE	DEP. VAR.: Ln(IE*)		DEP. VAR.: Ln(IE$_t$/IE$_0$)		DEP. VAR.: Ln(IE*)	DEP. VAR.: Ln(IE*)
	unrestricted	restricted	unrestricted	restricted	unrestricted	restricted
Constant	- 0.91	- 0.66	- 0.51	- 0.01	- 1.32	- 0.89
	(0.72)	(0.39)	(0.56)	(0.35)	(0.59)$^{++}$	(0.12)$^{++}$
ln(s$_k$)	- 0.31	- 0.29	- 0.23	- 0.20	0.10	0.10
	(0.10)$^{++}$	(0.09)$^{++}$	(0.08)$^{++}$	(0.08)$^{++}$	(0.03)$^{++}$	(0.04)$^{++}$
ln(s$_h$)	- 0.25	- 0.22	- 0.17	- 0.10	0.07	0.08
	(0.12)$^{++}$	(0.08)$^{++}$	(0.09)$^{+}$	(0.07)	(0.05)	(0.05)
ln(n+0.05)	0.66	-----	0.26	-----	- 0.43	-----
	(0.20)$^{++}$		(0.18)		(0.28)$^{+}$	
ln(a$_n$)	0.02	0.01	0.10	0.08	0.04	0.04
	(0.04)	(0.04)	(0.04)$^{++}$	(0.04)$^{++}$	(0.02)$^{+}$	(0.02)$^{+}$
ln(per cap. direct taxes)	0.07 (0.05)	0.08 (0.05)	0.02 (0.04)	0.03 (0.04)	- 0.02 (0.02)	- 0.01 (0.02)
ln(IE$_0$)	-----	-----	- 0.54	- 0.56	-----	-----
			(0.11)$^{++}$	(0.12)$^{++}$		
unweighted R^2	68.68 %	68.44 %	78.00 %	76.63 %	53.53 %	52.34 %
unweighted ad. R^2	58.25 %	60.55 %	68.56 %	68.83 %	39.00 %	41.13 %
unweighted SER	0.09	0.09	0.07	0.07	0.09	0.09
Wald test of restriction	not rejected p=0.76	-----	not rejected p=0.45	-----	not rejected p=0.48	-----
implied λ if α=1/3 (Kuznets Coef.)	- 0.45^{++}	- 0.43^{++}	- 0.35^{+}	- 0.34^{+}	0.15^{+}	0.15^{+}
implied φ if α=1/3 (hum. cap share)	0.27^{++}	0.25^{++}	0.25^{+}	0.17^{+}	0.23^{+}	0.27^{+}
implied β (speed of conv.)	-----	-----	5.55 %$^{++}$	5.86 %$^{++}$	-----	-----

$^{+}$: significant at the 10% level, $^{++}$: significant at the 5% level or better.

Although we found data of certainly lesser detail and possibly lower quality for the sample of developing countries, the hypothesis following from the model are again not rejected. The estimates suggest a significant positive Kuznets coefficient and Wald tests did not reject the restriction on the coefficient on ln(n+x), nor did they reject that the ratio of the estimated coefficients for ln(s_k) and ln(s_h) to the coefficient for ln(n+x) are different from the theoretically predicted values.

Note that the coefficient on the direct taxes is statistically not different from zero at the traditional confidence levels. This suggest that the redistributive efficiency of governments with respect to direct taxes is rather low. Also, the coefficient on the fraction of the population that completed higher education is not significant in the steady state regressions for the sample of developed countries, nor does it reflects - as it should - the Kuznets coefficient which has been derived based on the estimates for the coefficients on ln(s_k) and ln(s_h) assuming one third for the capital's share. A larger share of highly educated people does seem to increase the trend rate somewhat though in both developed and developing countries.

Note also that the effects of the growth related fundamentals on inequality are in absolute terms apparently much lower for the developing countries than their reported contribution to the growth process itself. For instance, compare the elasticities we found w.r.t. physical and human capital with the reported elasticities on economic growth in the literature. Mankiw, Romer and Weil [1992] report an elasticity of economic growth w.r.t. physical capital of around 0.70 for their comprehensive intermediate sample of 75 countries under the assumption of steady state. For OECD countries Nonneman and Vanhoudt [1996] find an elasticity of 0.30 for physical capital and around 0.28 for human capital under the assumption of steady state - which is very close to the absolute value of the elasticities we found for inequality w.r.t. these fundamentals in developed countries. In their dynamic specifications these elasticities are 0.50 and 0.18 respectively. Especially the accumulation of physical capital thus seems to contribute much more to the process of economic growth than it benefits the trend rate of income distribution. The impact of accumulating human capital is about the same for economic growth and the reduction of the trend rate of income distribution, and seems henceforth at first sight a more 'fair'policy. As for the developing countries, accumulating human capital widens the gap between rich and poor less seriously than accumulating physical capital.

IV. Summary and conclusion.

We have suggested that international differences in inequality can be understood using a combination of an elaborated Kuznets model which includes an augmented Solow model. In this kind of model output is produced from physical capital and technological knowledge, and is used for investment in physical and human capital, and consumption. Only skilled labor - which holds the stock of technological knowledge - is used in the production sector. Skilled labor is the result of training and exposing newly born workers to technology through education. However, a fraction of the eligible population decides not to become high skilled and drops out, resulting in unemployment, and hence persistent differences in income patterns. Inequality in this model has been modeled, and empirically confirmed, as a function of the top-to-bottom ratio. For developed countries we find inequality to be roughly of the form: $Gini=\frac{1}{2}[s_k^{2/3}.s_h^{1/2}.(n+x)^{-8/3}.a_n^{-1/25}.\tau^{-4/25}]^{-0.45}$; for developing countries this is approximately: $Gini=\frac{1}{4}[s_k^{2/3}.s_h^{1/2}.(n+x)^{-8/3}.a_n^{13/25}.\ \tau^{-3/25}]^{0.15}$. The redistributive efficiency of direct taxes is according to the estimates low. Contrary to recent models of inequality the data do not seem to indicate spill-overs.

The empirical results of this paper's model support Kuznets hypothesis. Moreover it significantly improves the explanatory power compared to the basic Kuznets model of inequality. For the developed countries the adjusted R^2 increases from at most one third up to 61 percent (about 70 percent in the dynamic specifications). The excellent fit of the regressions is in our view promising for the adoption of a neoclassical growth approach In models of inequality - it implies that theories based on easily observable fundamentals may be able to account for most of the cross-country variation in inequality in countries. However, future empirical research should preferably study which (endogenous) factors determine the Kuznets coefficient (λ).

The model also has implication for the dynamics of inequality (the evolution of the trend rates) when the economy is out of its steady state. Developed economies seem to evolve to their steady state level of inequality at about 6 percent p.a. This is exactly what the theory suggests.

According to this model, accumulating either form of capital increases per capita income and hence the income share which is available as remuneration for knowledge - which is held by skilled labor. The model provides a fairly good explanation for what happened both in developed and less developed countries. In developed countries it can be observed that the share of unskilled people has remained roughly the same over the considered time span (1975-1989), but the share of skilled labor which holds the technological knowledge has grown steadily. In such cases, investments in physical capital will benefit the marginal product of a growing number of persons, as will investments in human capital since new workers will be endowed with higher technological knowledge. Also, a higher savings rate leads to higher income in the steady state, which in turn leads to a higher level of human capital, even if the rate of human capital accumulation remains unchanged. Either form of capital in this case then lowers inequality. This explains the estimation results for the coefficients on physical and human capital in developed countries. Population growth and technological change, on the other hand, will have an impact on the accumulation of capital per worker and on the speed at which the fraction of skilled and unskilled (unemployed) in the work force evolve towards their steady state value. A lower growth rate of population will lead to a higher steady state value of both the stock of per capita physical and human capital, and less bodies contributing to the total taxes. Other things being equal, this implies that the increased share of income is distributed amongst a less fast growing number of skilled workers while the growing number of unemployed find their unemployment benefits to evolve relatively slowly, hence inequality increases. The coefficient on ln(n+x) reflects this hypothesis. The model thus yields a possible explanation for the empirical findings for developed countries.

In developing countries, growth rates of population are typically higher - yielding a lower per capita income due to lower steady state stocks of human and physical capital - and most of the additional workers moreover are unskilled. Over time a larger fraction of the working force will belong to the lower but more equal part of the distribution, so that population growth an sich lowers inequality. Possibly only a small and slowly evolving fraction of the working force will be able to work with the new technology embodied in new investments in physical capital, but the rewards from the investments - economic growth - needs to be divided among only a relatively low number of happy fews as well. Other things being constant accumulating either form of capital then widens the gap between rich and poor.

The main conclusion of this paper is that easily observable economic fundamentals are able to account for most of the cross-country variation in the level and trend rate of inequality.

Chart 1: the dynamics of k and w

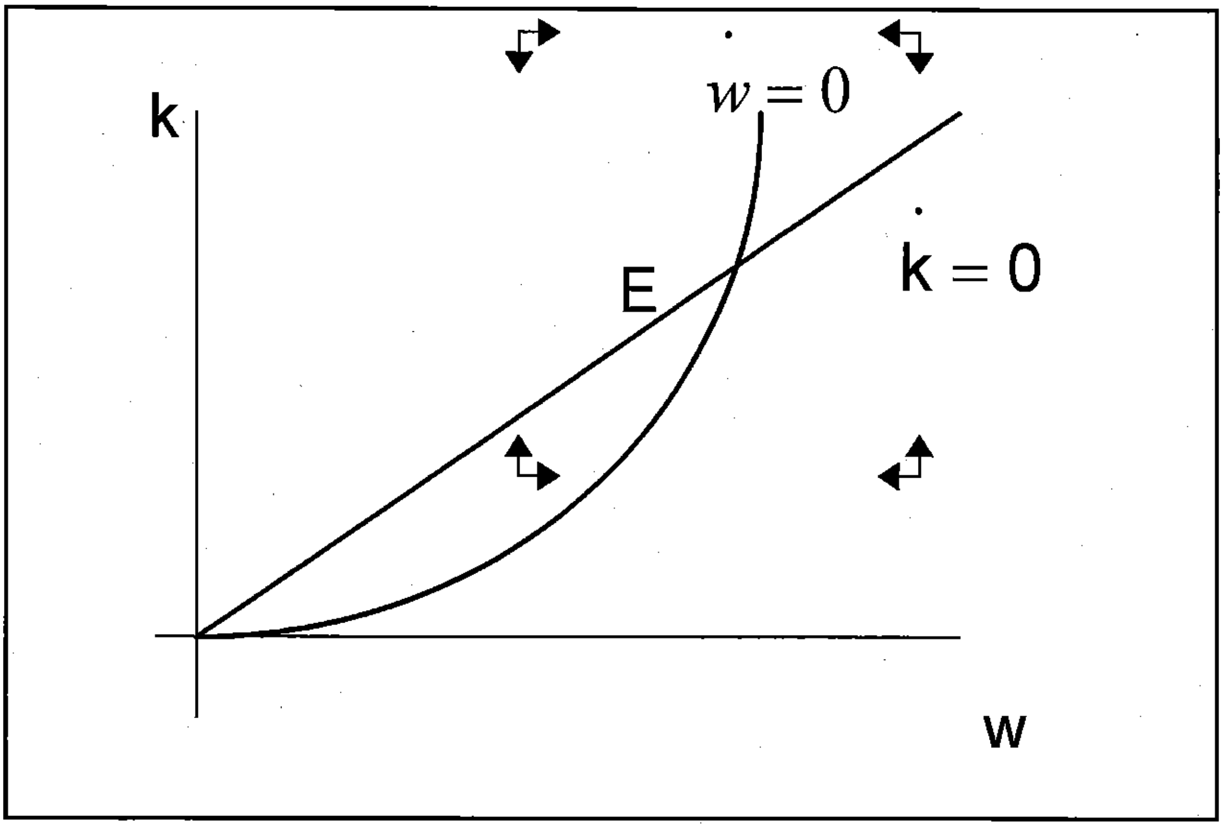
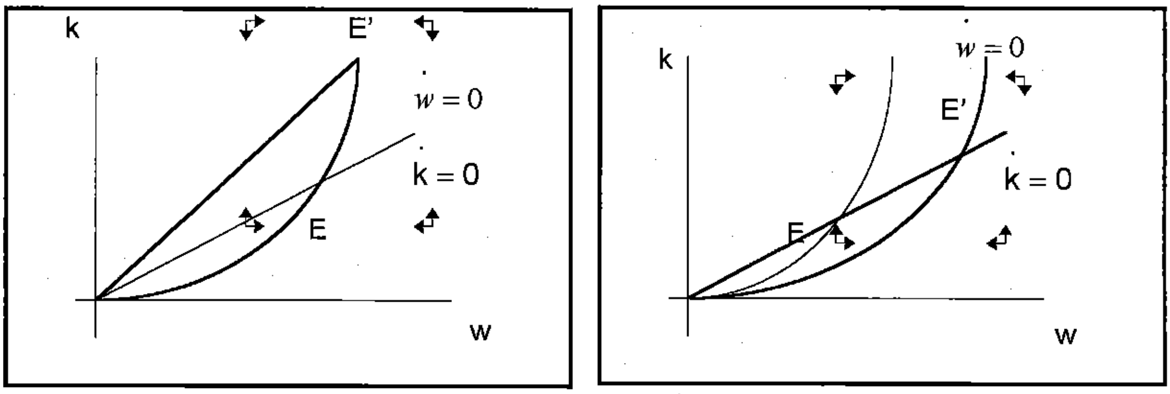
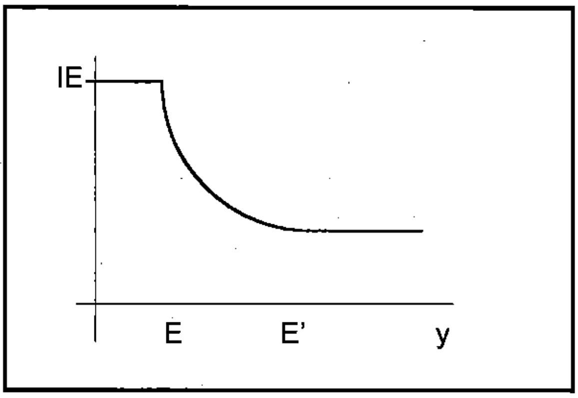


Chart 2: a shift in the 0-loci for k and w



and its effect on inequality if $\lambda<0$.



Appendix I: Dataset

Developed countries:

	Gini 1975	Gini 1989	s_k	s_h	n	a_n	τ (ct. PPP $)
Canada	0.3162	0.3600	0.24744	0.07390	0.01568	0.09577	5235.0736
Mexico	0.5829	0.5498	0.16769	0.03425	0.03361	0.03003	925.8931
USA	0.3393	0.3816	0.21006	0.06500	0.01370	0.17377	5083.6941
Japan	0.2900	0.3300	0.34256	0.05590	0.00761	0.07863	2498.1360
Austria	0.3353	0.3235	0.25319	0.05700	0.00650	0.02383	3444.0364
Belgium	0.2787	0.3035	0.21869	0.06060	0.00499	0.07420	5734.7545
Denmark	0.3036	0.3560	0.23006	0.06750	0.00403	0.09407	6830.1310
Finalnd	0.3030	0.3142	0.32475	0.05745	0.00584	0.06357	4557.6823
France	0.4407	0.3551	0.25906	0.05275	0.00897	0.04100	2614.6687
Germany	0.3519	0.3654	0.25162	0.04705	0.00560	0.03800	3527.2234
Ireland	0.3591	0.3435	0.24919	0.06160	0.01465	0.04393	2905.7180
Italy	0.3985	0.3274	0.24725	0.03680	0.00775	0.02850	3692.6464
Netherlands	0.2847	0.2960	0.21769	0.07790	0.01187	0.06447	4371.3967
Norway	0.3780	0.3376	0.29625	0.07070	0.00571	0.05030	5190.4655
Poland	0.2568	0.2671	0.30294	0.04900	0.00890	0.05510	1036.5254
Portugal	0.4101	0.3695	0.21162	0.04160	0.01213	0.01593	1149.5818
Sweden	0.3338	0.3133	0.21706	0.08200	6.79E-04	0.07973	6406.2388
Turkey	0.4400	0.4000	0.22844	0.03705	0.03182	0.01790	645.5346
UK	0.2928	0.3800	0.17431	0.05690	0.00351	0.06730	3706.9618
Australia	0.3391	0.3732	0.27075	0.06060	0.01829	0.11907	5258.5427
New Zealand	0.2919	0.3658	0.23569	0.05430	0.01050	0.10397	6098.4697

Developing countries:

	Gini 75-88	s_k	s_h	n	a_n	τ (ct. PPP $)
Bangladesh	0.34000	0.03821	0.01480	0.02730	0.00903	11.9809
Bolivia	0.42040	0.08182	0.03230	0.02640	0.04237	11.4703
Chile	0.46000	0.14006	0.03810	0.01580	0.04703	264.5578
Colombia	0.45000	0.17234	0.02370	0.01900	0.03023	95.9169
Costa Rica	0.42000	0.18313	0.05735	0.02350	0.05860	82.7999
Ecuador	0.40000	0.21878	0.03830	0.02875	0.05533	190.2172
Egypt	0.38000	0.06498	0.04910	0.02705	0.04983	87.7345
El Salvador	0.40000	0.07920	0.03455	0.01550	0.01423	34.4596
Ghana	0.36320	0.05048	0.03255	0.02495	0.00483	32.9484
India	0.42000	0.17868	0.03030	0.02205	0.01907	19.5534
Iran	0.46000	0.25910	0.05095	0.03220	0.01400	66.4502
Jordan	0.42050	0.21413	0.05985	0.02990	0.03857	42.0578
Malaysia	0.48000	0.30371	0.05940	0.02465	0.01380	294.5013
Mauritius	0.42530	0.10185	0.04780	0.01445	0.01213	153.9542
Pakistan	0.36000	0.11136	0.02130	0.03030	0.02060	23.3173
Panama	0.57000	0.17332	0.05090	0.02210	0.05720	128.4664
Peru	0.46050	0.19957	0.02790	0.02455	0.06527	28.0375
Philippines	0.45000	0.17871	0.01730	0.02585	0.09737	56.4877
Singapore	0.42000	0.38648	0.03045	0.01225	0.02390	497.3201
Sri Lanka	0.45000	0.22433	0.02720	0.01600	0.00663	46.5078
Thailand	0.47000	0.19399	0.03600	0.02230	0.03237	101.8219
Tunesia	0.40000	0.13730	0.05335	0.02575	0.01740	104.3683

Appendix II: Properties of the steady state and the log-linearization around it.

The system of per capita growth rates (see (7) in the main text of the paper) is here written as:

$$\text{(A)}\quad \begin{aligned} \frac{d\ln(k)}{dt} &= A\cdot s_k\cdot e^{-(1-\alpha)\cdot\ln(k)}\cdot e^{(1-\alpha)\cdot\ln(w)}-(n+x) \\ \frac{d\ln(w)}{dt} &= A\cdot e^{\varphi\cdot\ln(h)}\cdot e^{-\ln(w)}\cdot\left[a_n\cdot(n+x)\right]^{1-\varphi}-(n+x) \\ \frac{d\ln(h)}{dt} &= A\cdot s_h\cdot e^{\alpha\cdot\ln(k)}\cdot e^{(1-\alpha)\cdot\ln(w)}-(n+x) \end{aligned}$$

with the associated steady states:

$$\text{(B)}\quad \begin{aligned} & A\cdot s_k\cdot e^{-(1-\alpha)\cdot\ln(k)}\cdot e^{(1-\alpha)\cdot\ln(w)}=(n+x) \\ & A\cdot e^{\varphi\cdot\ln(h)}\cdot e^{-\ln(w)}\cdot\left[a_n\cdot(n+x)\right]^{1-\varphi}=(n+x) \\ & A\cdot s_h\cdot e^{\alpha\cdot\ln(k)}\cdot e^{(1-\alpha)\cdot\ln(w)}=(n+x) \end{aligned}$$

Take a first order Taylor approximation of (A) evaluated at the steady state (B). The system becomes:

$$\text{(C)}\quad \begin{bmatrix} \frac{d\ln(k)}{dt} \\ \frac{d\ln(w)}{dt} \\ \frac{d\ln(h)}{dt} \end{bmatrix} = \begin{bmatrix} -(1-\alpha)(n+x) & (1-\alpha)(n+x) & 0 \\ 0 & -(n+x) & \varphi(n+x) \\ \alpha(n+x) & (1-\alpha)(n+x) & -(n+x) \end{bmatrix} \begin{bmatrix} \ln(\frac{k}{k_*}) \\ \ln(\frac{w}{w_*}) \\ \ln(\frac{h}{h_*}) \end{bmatrix}$$

Stability properties and speed of convergence

1. Stability conditions of the steady state

In order to find out whether the system is stable, sadle-path stable or unstable, we need to determine the sign of the determinant and the eigenvalues of the characteristic matrix. We used mathematica for this purpose:

Mathematica-Input:

```
CharMatrix={ {-(1-α)*(n+x), (1-α)*(n+x),     0      },
             {0,             -(n+x),          φ*(n+x)},
             {α*(n+x),       (1-α)*(n+x),     -(n+x)}};
MatrixForm[CharMatrix]
Simplify[Det[CharMatrix]]
Eigenvalues[CharMatrix];
Simplify[%]
```

Mathematica-Output:

$-((1 - \alpha)(n + x))$	$(1 - \alpha)(n + x)$	0
0	$-n - x$	$\varphi(n + x)$
$\alpha(n + x)$	$(1 - \alpha)(n + x)$	$-n - x$

$(-1 + \alpha)(1 - \varphi)(n + x)^3$ // Determinant < 0 => need 3 neg. roots for a stable equilibrium.

{

$-n - x,$

$(-2n + \alpha n - 2x + \alpha x - \sqrt{[(\alpha^2 + 4\varphi - 4\alpha\varphi)(n + x)^2]})/2,$

$(-2n + \alpha n - 2x + \alpha x + \sqrt{[(\alpha^2 + 4\varphi - 4\alpha\varphi)(n + x)^2]})/2$

} // 3 negative roots -> stable steady state

2. speed of convergence ?

One of these roots will determine how fast the system converges to the equilibrium. In a system of linear differential equations, the least negative root would be dominant. However, in a system of non-linear differential equations this is not necessary the case. Let $-\beta$ be the dominant root. We can rewrite the system now as:

$$\text{(D)} \quad \begin{aligned} \ln(k_t) &= ct_1 \cdot e^{-\beta \cdot t} + \ln(k_*) \\ \ln(w_t) &= ct_2 \cdot e^{-\beta \cdot t} + \ln(w_*) \\ \ln(h_t) &= ct_3 \cdot e^{-\beta \cdot t} + \ln(h_*) \end{aligned}$$

Using the initial conditions ($k(0)=k_0$, $w(0)=w_0$, $h(0)=h_*$, $k(\infty)=k_*$, $w(\infty)=w_*$, $h(\infty)=h_*$), we can solve for the constants in (D), so that the particular solution for the system becomes:

$$\text{(E)} \quad \begin{aligned} \ln(k_t) &= \left[\ln(k_0) - \ln(k_*)\right] \cdot e^{-\beta \cdot t} + \ln(k_*) \\ \ln(w_t) &= \left[\ln(w_0) - \ln(w_*)\right] \cdot e^{-\beta \cdot t} + \ln(w_*) \\ \ln(h_t) &= \left[\ln(h_0) - \ln(h_*)\right] \cdot e^{-\beta \cdot t} + \ln(h_*) \end{aligned}$$

Since $\ln(IE_t)$ equals $\ln(1-\alpha)^{\lambda} + \lambda \ln(y_t) - \lambda\varepsilon \ln(\tau)$ and $\ln(y_t)=\ln(A)+ \alpha \ln(k_t) + (1-\alpha) \ln(w_t)$, the time path for $\ln(IE)_t$ is:

$$\ln(IE_t) = (1-e^{-\beta \cdot t}) \cdot \ln(IE_*) + e^{-\beta \cdot t} \cdot \ln(IE_0)$$

or

(F) $$\ln\left(\frac{IE_t}{IE_0}\right) = (1-e^{-\beta \cdot t}) \cdot \left[\ln(IE_*) - \ln(IE_0)\right]$$

which is equation (13) in the main text of the paper.

References

Adelman, I., and Robinson, S., 1989, "Income Distribution and Development" in H. Chenery and T.N. Srinivasan (eds.), *Handbook of Development Economics*, Vol. 2., p. 949-1003, Amsterdam, North-Holland.

Anand, S. and Kanbur, S. "Inequality and Development: a Critique", *Journal of Development Economics*, 41 (1993): 19-43.

Aghion, P. and Bolton, P., "Distribution and Growth in Models of Imperfect Capital Markets", *European Economic Review*, 36 (1992): 603-11.

Barro, R. and Lee, J, "Data Set for a Panel of 138 Countries", Harvard University, 1994.

Deininger, K. and Squire, L., "Measuring Income Inequality: a New Database", *World Bank Economic Review (international)*, 10 (1995): 565-91, The World Bank.

Galor, O. and Tsiddon, D., "Income Distribution and Growth: the Kuznets Hypothesis Revisited", *Economica*, 63 (1996): S103-17.

Kuznets, S., "Economic Growth and Income Inequality", *American Economic Review*, 45 (1955): 1-28.

Levine, R., and Renelt, D ., "A Sensitivity Analysis of Cross-Country Growth Regressions", *American Economic Review*, 82 (1992): 942-63.

Mankiw, G., Romer, D. and Weil, D., "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, 107 (1992): 407-37.

Nonneman, W. and Vanhoudt, P. "A Further Augmention of the Solow Model and the Empirics of Economic Growth for OECD countries", *Quarterly Journal of Economics*, 111 (1996): 943-53.

OECD, Economic Outlook, no 54 and 55, *Organization for Economic Cooperation and Development*, Paris.

Persson, T. and Tabellini, G., "Is Inequality Harmful for Growth?", *American Economic Review*, 84 (1994):600-21.

Rebelo, S., "Long-Run Policy Analysis and Long-Run Growth", *Journal of Political Economy*, 99 (1992): 500-21.

Romer, P., "Endogenous Technological Change", *Journal of Political Economy*, 98 (1990): S71-S02.

Summers, R. and Heston, A., "The Penn World Tables (Mark 5): an Expanded Set of International Comparisons", *Quarterly Journal of Economics*, 106 (1991): 327-68.

United Nations Development Report, Various Issues, *The United Nations*, New York.

Address for correspondence:

Patrick Vanhoudt
University of Antwerp (UFSIA)
Econ. Dept., room B-128
Prinsstraat 13, B-2000 Antwerp, Belgium
Phone: +32 - 3 - 220 40 50
Fax: +32 - 3 - 220 40 26
e-mail: dse.vanhoudt.p@alpha.ufsia.ac.be