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# Short-run and Long-run Dynamics of Growth, Inequality and Poverty in the Developing World

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Growth, inequality, and poverty are central elements of the development process. However the mutual effects and directions of causality have been, and remain, one of the most controversial issues. After introducing a simple theoretical framework we derive some fundamental relations between growth, inequality and poverty. In the empirical part we test for unit roots and cointegration and apply GMM techniques on an error correction model (ECM) to estimate the pairwise short-run and long-run dynamics for income growth and changes in inequality and poverty in a panel of 114 developing countries and six regional subpanels for 1981 to 2005. The results confirm the relations of the theoretical framework; the evidence shows that in nearly all cases the variables exhibit a short-run and long-run relationship. The findings reveal positive bidirectional causality between growth and inequality as well as between inequality and poverty, and negative bidirectional causality between growth and poverty. Furthermore, the evidence shows that the level of development affects the poverty-reducing effect of growth, and that growth has benefited the poor regions far less. In summary, we show that growth, income distribution and poverty reduction are strongly inter-related, so a sucessful development strategy requires effective, country-specific combinations of growth and distribution policies.

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|---|---|
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# 1 Introduction

In recent years a series of theoretical and empirical contributions have studied the relations between growth, inequality and poverty. It has become ever more apparent that successful development strategies should not address each of these phenomena in isolation, but rather look at their interdependences and interactions. Bourguignon (2004) refers to this relationship as the poverty-growth-inequality triangle; he points out that there is a two way relationship between growth and distribution which can be divided into the effects of growth on distribution and the effects of inequality on growth. This interaction, in turn, has an effect on absolute poverty and poverty reduction, so a change in poverty can be shown to be linked to growth, distribution and the change in distribution. Adams (2004) argues that economic growth represents an important means for reducing poverty in the developing world; his results show that since income distributions are relatively stable over time, economic growth has the general effect of raising incomes for all members of society, including the poor. This result is also consistent with Dollar and Kraay (2002) who point out that several determinants of growth – such as the rule of law, openness to international trade, and developed financial markets – have little systematic effect on the share of income that accrues to the bottom quintile. Consequently these factors benefit the poorest fifth of society as much as they do everyone else. This makes clear that promising development policies and poverty reduction should be based on possible relations between growth, inequality and poverty. These relationships are the focus of numerous empirical studies.

As early as in the 1950s Kuznets (Kuznets 1955) suggested the inverted U-curve relation between these variables, indicating that economic inequality increases over time while a country is developing; then after a certain average income is attained, inequality begins to decrease. Using standard growth regressions augmented by inequality measures OLS cross country estimates in most cases show a negative impact of inequality on growth (e.g. see Perotti (1993, 1996), Alesina and Rodrik (1994) and Persson and Tabellini (1994), while recent panel methods tend to exhibit a positive effect, for instance Li and Zou (1998) and Forbes (2000).

Further, the effect of growth on poverty also is not as unambiguous as it appears to be at first sight. Of course, when holding inequality constant, higher economic growth reduces poverty by increasing the income of the poor by the same rate as the income of the total population. However, is growth really pro-poor, or is the combined effect of growth and inequality maybe counterproductive in terms of fighting poverty? Using a large sample of countries spanning the past four decades Dollar and Kraay (2002) find out that the average income of the poorest fifth of a country on average rises or falls at the same rate as the average. Naschold (2004) argues that the level of development proxied by per capita consumption impacts on the poverty reducing effect of growth. He shows that consumption growth elasticities in LDCs are only between one third and one half of the size of elasticities in other developing countries. Squire (1993) and Bruno, Ravallion and Squire (1998) argue that economic growth can be expected to reduce poverty, but the latter also point out that poverty is also sensitive to inequality and even small changes in the overall distribution of inequality can lead to sizeable changes in the incidence of poverty. Recent studies have also shed light on the role of distribution changes in poverty reduction, like Heltberg (2002), Bourguignon (2003) and Ravallion (2005). These authors emphasize that poverty elasticity depends strongly on the degree of inequality and that growth reduces poverty more efficiently in less inegalitarian countries. To highlight the relations between inequality and growth as well as poverty and growth, a possible causality between inequality and poverty should also be taken in consideration.

This paper expands on the above literature by considering short-run and long-run dynamics between growth, inequality and poverty. It differs from existing studies on the relationship between growth, inequality and poverty in three respects. Firstly, it considers all possible relations between these three variables by pairs, so we can clearly identify the causal directions of the triangle. Secondly, the study is based on recently developed tests for panel unit root and heterogeneous panel cointegration. Furthermore, panel based error correction models are applied to explore the pairwise relationship between growth, inequality and poverty for a large panel of developing countries, and we use Arellano and Bond Difference GMM estimator. Thirdly, in addition to the entire panel of 114 developing countries we try to capture possible regional differences by analyzing differentiated country sets.

The paper proceeds as follows. Section 2 presents a simple theoretical model of the relations between growth, inequality and poverty. Section 3 presents the empirical investigation including the data, the methodology and the results of the panel unit root tests, the panel cointegration tests, and the error correction models. Section 4 concludes.

# 2 Some fundamental relations between growth, inequality, and poverty

Before we focus on the empirical causality relations between per capita income growth, poverty reduction, and inequality we first recall some fundamental theoretical relations between the elements of this "triangle of development". If income and income variety are generated by a productive process and productivities we can set a benchmark by looking at "the triangle" for a linear homogeneous production process. From this process we can derive productivities of various groups and explain the conection between the elements of the triangle.

**Production and per capita income:** For a linear homogeneous production process $[Y = F(AL, K)]$ average productivity and hence per capita income is $y = \frac{Y}{L} = f(k)\,A$, where $L$ is physical labor, $K$ is the accumulative factor of production (capital), $k$ is capital intensity[1] and $A$ is the technological productivity

[1] Capital intensity for labor in efficiency units.

index. Hence, per capita income growth is given by

$$\frac{\dot{y}}{y} = \alpha \frac{\dot{k}}{k} + \frac{\dot{A}}{A}, \tag{1}$$

with $\alpha = f' \frac{k}{f}$ being the elasticity of production of capital. As long as the stationary state has not been reached, we have two engines of growth: accumulation of capital $\frac{\dot{k}}{k} > 0$ and technical progress $\frac{\dot{A}}{A}$. Under stationary conditions $\frac{\dot{k}}{k} = 0$. For most developing economies we can assume that there is no stationary $\frac{\dot{k}}{k} > 0$ even if this element is potentially of decreasing importance.

**Inequality:** In this simple view income differentials and inequality are generated by differentials in productivity and ownership of productive assets $K$. For simplicity we assume that the share $n_L$ of total population $N$ defines the labor force $L = n_L N$ and the share $n_K$ defines the number of owners of the accumulative assets $n_K N = 1$, which is normalized to one. If $L > 1$ and capital income is larger than wage income[2] we can define an inequality measure $\delta$ with respect to productive activities by $\delta = \frac{rK}{w(L)L} = \frac{f'}{A(f-f'k)}k$. Hence, changes in inequality are given by

$$\frac{\dot{\delta}}{\delta} = \left(1 - \frac{1}{\sigma_{L,K}}\right)\frac{\dot{k}}{k} - \frac{\dot{A}}{A}, \quad \text{for} \quad (\sigma_{L,K}) > 1 \tag{2}$$

where $\sigma_{L,K} = -\frac{f'}{ff''}\frac{f-f'k}{k}$ is the elasticity of substitution in production. According to this relation, rising capital intensity would increase inequality if both factors are easy to substitute $\sigma_{L,K} > 1$. A simultaneous adoption of available technologies would improve labor productivity and lead to more equality. In fact it is easy to recall that (2) can be Kuznets' inverted U-curve relation if an economy is still transitioning towards a stationary state.[3]

**Poverty:** To identify the link to poverty we look at an absolute poverty level. Labor is not poor if it reaches at least a productivity generating a wage slightly above the poverty level $\bar{\varphi} \leqq w = A\left(f\left(k\right) - f'\left(k\right)k\right)$. Again, due to the development process $k$ and $A$ may grow over time and changes the number of people being more productive than required to obtain an income above the poverty line. Therfore, the first step is to find out which relation of $\dot{k}$ and $\dot{A}$ allows workers to reach at least the income level of the poverty line:

$$\frac{\dot{k}}{k} = -\frac{(\sigma_{L,K})}{\alpha}\frac{\dot{A}}{A}.$$

[2] Capital income and wage are determined by each marginal productivity.

[3] If we assumed a neoclassical growth model $\frac{\dot{k}}{k}$ would be large at the beginning and continously decrease to zero. Hence, for a constant rate of technology improvement $\frac{\dot{A}}{A}$ it is easy to find a converted u-curve in this dynamic process.

If technical progress is positive at rate $\frac{\dot{A}}{A}$, productivity is growing. Hence, the produictivity of the just not poor ($\bar{\varphi} \leqq w$) could already be reached with a lower capital intensity $\frac{\dot{k}}{k} < 0$. Therefore, using the definition of capital intensity $k \equiv K/AL$, we can determine how many additional workers $\dot{L}/L > 0$ could be employed at this productivity level; this increase in employed labor at exactly this productivity level defines a reduction of poverty. More workers $\dot{L}/L > 0$ have just crossed the poverty line

$$\frac{\dot{L}}{L} = \frac{\dot{K}}{K} - \frac{\dot{A}}{A} - \frac{\dot{k}}{k} = \frac{\dot{K}}{K} - \left(1 - \frac{(\sigma_{L,K})}{\alpha}\right)\frac{\dot{A}}{A} \quad \text{for} \quad (\sigma_{L,K}) > 1 > \alpha \tag{3}$$

In other words, if capital is accumulated and capital intensity $\dot{k}$ or technology $\dot{A}$ changes during the growth process, we obtain a rising number of people who are productive just above the poverty line if $(\sigma_{L,K}) > \alpha$. As long as we assume $(\sigma_{L,K}) > 1$ (see above) and $1 > \alpha$ , poverty will be reduced with positive technical progress.

When looking at (1), (2) and (3) we can see that all elements of the "triangle of development" have either $\frac{\dot{A}}{A}$ or $\frac{\dot{k}}{k}$ or both as common factor. They are connected by these common factors. These partial links can be discussed in pairs.

Income growth and inequality: Looking at (1) and (2), income growth and inequality are connected by two common factors, $k$ and $A$. Increasing capital intensity positively relates both to income growth and inequality. According to this link per capita income growth would go hand in hand with higher inequality. The second common factor $A$ would point towards the other direction. Technical progress improves per capita income but tends to decrease disparity since technical progress increases labor productivity. Therefore, the question which component is dominant needs to be answered by empirical analysis. In the early stages of development when the capital intensifying process can be expected to be strong, high income growth and increasing inequality seems to be the most likely pattern. This condition describes the dynamics to the left of the maximum of the Kuznets curve. If the economy moves closer to the stationary state and $\dot{k}$ converges towards zero the economy can be expected to switch to the right of the maximum of the Kuznets curve.

Income growth and poverty: Looking at (1) and (3), income growth and poverty are connected by technology growth $A$. Technology growth improves productivity, so a rising number of people can pass the poverty line. At the same time technical growth is a general driver of per capita income growth. Therefore, $A$ links income growth and poverty reduction in a positive way.

Inequality and poverty: Looking at (2) and (3), income growth and poverty are also connected by technology growth $A$. Technology growth improves productivity of labor, so that higher labor productivity leads to a less unequal income distribution. At the same time an increasing number of people can pass the poverty line. Therefore, $A$ links decreasing inequality and poverty reduction. We simultaneously obtain less inequality and less poverty.

[here insert **Table 1 :** Theoretical relations between growth, inequality, and poverty]

While table 1 summarizes the most likely theoretical relations we should be aware that these partial relations could be overcompensated, and that differences in the aggregate production technology due to variations in the industry structure can easily generate reverse observations. Also, a simple reproduction of production theory mechanics does not lead to a theoretical causality direction. In other words, the fact that a common factor, productivity growth $A$, links income growth and poverty reduction does not enable us to identify the direction of causalities. Does the improvement in productivity of the poor, which leads to poverty reduction, cause an increase in per capita income growth, or do higher per capita income growth rates drag more people out of poverty (pro poor growth)? It is possible to derive both causal directions from the theoretical relations.

# 3 Empirical evidence

## 3.1 Data

The analysis is based on data from the World Bank´s PovcalNet.[4] This data set includes data on income and poverty and inequality measures for a multiplicity of developing countries. To obtain a balanced panel some incomplete country time series were dropped so that the dataset used in the analysis refers to a balanced panel of 114 countries. The reference years currently available are 1981, 1984, 1987, 1990, 1993, 1996, 1999, 2002, and 2005.[5] In addition to analyzing the entire panel we also try to capture possible differences by splitting the panel and analyzing differentiated country sets at different development levels. A possible segmentation could be a division by income group, however this does not allow us to account for regional differences. Hence we use the World Bank´s regional segmentation into six subpanels, namely East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, South Asia, and Sub-Saharan Africa. We can then analyse varying conditions in terms of culture, geography, administration and institutions. In the following the variables used in the analysis are defined and described. Table 2 presents the descriptive statistics including the number of observations, the mean and the standard deviation for the aggregate panel and the six subpanels.

[4] See Chen and Ravallion (2007). The data set is available at http://iresearch.worldbank.org/PovcalNet.

[5] Appendix 1 contains a detailed description of the dataset and the countries included in the analysis.

[here insert**Table 2 :** Summary and descriptive statistics]

**mean income:** $y_{i,t}$ Mean income $y_{i,t}$ is measured by the average monthly per capita income/consumption expenditure (PPP) from the survey in 2005.

**headcount:** $h_{i,t}$ Headcount $h_{i,t}$ denotes the percentage of population living in households with consumption or income per person below the poverty line. The analysis is based on a $1.25/day poverty line and income data at 2005 prices, adjusted for purchasing power parity (PPP).[6]

**Gini coefficient:** $gini_{i,t}$ We use the Gini coefficient $gini_{i,t}$ in its common definition as a measure of inequality.

To obtain a first impression of the relationships between growth, inequality and poverty we plot these variables by pairs. The diagrams presented in figures A1, A2 and A3 also include the prediction graphs of the linear regressions. The figures show a weak positive relationship between inequality and growth and inequality and poverty and a strong negative relationship between growth and poverty. The correlation matrix (table A1) confirms these results, showing a weak positive correlation between growth and inequality and inequality and poverty and a strong negative correlation between growth and poverty. However, it is a moot point whether and if so to what extent these variables have a causal effect on each other. The concept of the error correction model is a possibility to test these causality relations in the short-run and in the long-run.

## 3.2 Estimation

**Methodology:** Based on the methodology described by Yasar et al. (2006) we suggest applying a generalized one-step ECM to explore the pairwise short-run and long-run dynamics between growth, changes in inequality, and poverty, and to use a panel data analysis and GMM estimation. We prefer dynamic panel estimators for various reasons. The dynamic panel procedure allows us to control for country specific effects, whereas the OLS estimator assumes that the intercept that captures the effect of all omitted and unobservable variables is the same for all countries. This individual effect may correlate with the included explanatory variables, hence omitting the individual effect would become part of the error term, which would lead to a bias in the estimates. Furthermore, in comparison to the standard fixed effect estimator, GMM estimation additionally circumvents the bias associated with including a lagged dependent variable as a regressor and enables us to calculate consistent and efficient estimates. Additionally, by combining the time series dimension with the cross-sectional

[6] We also run the analysis using a $1/day and $2/day poverty line. The results are robust to those of the $1.25/day poverty line.

dimension, the panel data gives a richer set of information to exploit the relationship between the dependent and independent variables, reduce collinearity among the explanatory variables, increase the degrees of freedom and give more variability and efficiency. More specifically, our point of departure is a bivariate autoregressive-distributed lag model

$$y_{i,t} = \alpha_0 + \sum_{j=1}^{2} \alpha_j y_{i,t-j} + \sum_{j=0}^{2} \delta_j x_{i,t-j} + f_i + u_{i,t} \quad (4)$$

$$x_{i,t} = \beta_0 + \sum_{j=1}^{2} \beta_j x_{i,t-j} + \sum_{j=0}^{2} \gamma_j y_{i,t-j} + \eta_i + \nu_{i,t} \quad (5)$$

where index i=1...N refers to the country and t=1...T to the period. This method allows us to include specific effects for each country ($f_i$ and $\eta_i$). The disturbances $u_{i,t}$ and $\nu_{i,t}$ are assumed to be independently distributed across countries with a zero mean. They may display heteroskedasticity across time and countries, though. Following Granger (1969) there is Granger causality from $x$ to $y$ if past values of $x$ improve the prediction of $y$ given the past values of $y$. With respect to the model $x$ Granger causes $y$ if not all $\gamma_j$ are zero. Respectively, Granger causality from $y$ to $x$ occurs if not all $\beta_j$ are equal to zero. However Engle and Granger (1987) have shown that, if the series $x$ and $y$ are cointegrated, the standard Granger causality test is misspecified. In this case an error-correction model (ECM) should be used instead. So the first step of the standard procedure is a unit root and a cointegration test. On the basis of the results it is determined whether to use the Granger causality framework or an ECM model to test causality.

**Panel unit root test:** The Granger causality test requires the variables to be stationary. To check the stationarity of the data two common panel unit root tests are used, the IPS test by Im, Pesaran and Shin (2003) and the Fisher-type test by Maddala and Wu (1999) and Choi (2001).

Formally the test equation of both tests is

$$\triangle y_{i,t} = \mu_i + \beta_i y_{i,t-1} + \varepsilon_{it}. \quad (6)$$

The null hypothesis is that each cross-section series in the panel has a unit root. The alternative hypothesis is that there is at least one cross-sectional series in the panel that is stationary. Additionally, the formulation allows $\beta_i$ to differ across cross-sections so that both tests allow for heterogeneity.

$$H_0 \ : \ \beta_i = 0 \quad for \ all \ i \quad (7)$$

$$H_1 \ : \ \beta_i < 0, \quad i = 1, 2, ..., N_1, \quad \beta_i = 0, \quad i = N_1 + 1, N_2 + 1, ...N. \quad (8)$$

[here insert**Table 3:** Panel unit root test]

The IPS test is a t-bar statistic based on the (augmented) Dickey-Fuller (Dickey and Fuller 1979) statistic. It computes the sample mean of the individual unit root tests for each of the N cross-section units. The main idea of the Fisher-type unit root test is to combine p-values from a unit root test applied to each cross-section in the panel data. While both IPS and the Fisher-type test combine information based on individual unit root tests, the crucial difference between the two is that the IPS test combines the test statistics while the Fisher-type test combines the significance levels of the different tests. Table 3 presents the results of both tests for the three variables in levels and in first differences. The results indicate that for the variables in levels the null hypothesis of a unit root cannot be rejected. However the test coefficients of the differenced variables are highly significant and show stationarity in all three cases regardless of whether the trend is included in the test or not. On this account the following analysis is based on the differenced data, namely income growth and the changes in poverty and inequality.

**Panel cointegration test:** Since the panel unit root tests indicate that the variables are integrated of order one I(1), the pairwise cointegration will be tested using the panel cointegration test developed by Pedroni (1999, 2004). This test allows for heterogeneity in the panel by permitting heterogenous slope coefficients, fixed effects and individual specific deterministic trends. The test contains seven cointegration statistics, four based on pooling the residuals along the "within-dimension" which assume a common value for the unit root coefficient, and three based on polling the residuals along the "between dimension" which allow for different values of the unit root coefficient. The basic idea of both classes is to first estimate the hypothesized cointegration relationship separately for each group member of the panel and then pool the resulting residuals when constructing the test for the null of no cointegration. Table 4 presents the results for the three pairs of variables. In all cases the null of no cointegration is rejected on at least the 5% significance level, indicating that all three pairs of variables exhibit a cointegration relationship.

[here insert**Table 4:** Panel cointegration test]

**Error correction model:** Engle and Granger (1987) have shown that when the series $x$ and $y$ are cointegrated a standard Granger-causality test as presented in the equations (4) and (5) is misspecified. It does not allow for the distinction between the short-run and the long run-effect. At this point an error correction model (ECM) should be used instead. It is a linear transformation of the ADL models above and provides a link between the short-run and the long-run effect (Banerjee et al. 1993, 1998).

$$
\begin{aligned}
\Delta y_{i,t} &= (\alpha_1 - 1)\Delta y_{i,t-1} + \delta_0 \Delta x_{i,t} + (\delta_0 + \delta_1)\Delta x_{i,t-1} \\
&\quad + \lambda(y_{i,t-2} - \phi x_{i,t-2}) + f_i + u_{i,t} \qquad (9) \\
\Delta x_{i,t} &= (\beta_1 - 1)\Delta x_{i,t-1} + \gamma_0 \Delta y_{i,t} + (\gamma_0 + \gamma_1)\Delta y_{i,t-1} \\
&\quad + \kappa(x_{i,t-2} - \phi y_{i,t-2}) + \eta_i + \nu_{i,t} \qquad (10)
\end{aligned}
$$

The coefficients $(\alpha_1 - 1)$, $\delta_0$ and $(\delta_0 + \delta_1)$ as well as $(\beta_1 - 1)$, $\gamma_0$ and $(\gamma_0 + \gamma_1)$ capture the short-run effect, while the coefficients $\lambda$ and $\kappa$ of the error correction term give the adjustment rate at which short-run dynamics converge to the long-run equilibrium relationship. If $\lambda$ and $\kappa$ are negative and significant a relationship between x and y exist in the long run. The standard procedure is a two step method where first the error correction term is obtained by saving residuals of separate estimation of the long-run equilibrium, and then the model is estimated. However, the two-stage error correction models have been criticized in the literature. Banerjee et al. (1998) argue there can be a substantial small-sample bias, compared to a single-equation error correction model where the long-run relation is restricted to being homogeneous. So in this study a one-step procedure is used to indicate to short-run and long-run dynamics. The generalized one-step ECM is transformed as follows:

$$
\begin{aligned}
\Delta y_{i,t} &= (\alpha_1 - 1)\Delta y_{i,t-1} + \delta_0 \Delta x_{i,t} + (\delta_0 + \delta_1)\Delta x_{i,t-1} \\
&\quad + \lambda(y_{i,t-2} - x_{i,t-2}) + \theta x_{i,t-2} + f_i + u_{i,t} \qquad (11) \\
\Delta x_{i,t} &= (\beta_1 - 1)\Delta x_{i,t-1} + \gamma_0 \Delta y_{i,t} + (\gamma_0 + \gamma_1)\Delta x_{i,t-1} \\
&\quad + \kappa(x_{i,t-2} - y_{i,t-2}) + \vartheta x_{i,t-2} + \eta_i + \nu_{i,t} \qquad (12)
\end{aligned}
$$

where the long-run multiplier is restricted to being homogeneous $\phi = 1$. Using this form of the error correction model allows us to calculate the true long-run relationship between $x$ and $y$, which can be written as $1 - (\hat{\theta}/\hat{\lambda})$ and $1 - (\hat{\vartheta}/\hat{\kappa})$, so that the one step ECM permits us to directly calculate the short-run and long-run elasticities between growth, inequality and poverty. To avoid the problem of biased estimates through a possible correlation between the lagged endogenous variable and the error term we use the Difference GMM estimator developed by Arellano and Bond (1991). The estimator uses all lagged observations to instrument the lagged endogenous variable and circumvent a possible bias. This moment conditions of the instruments can be checked using the Sargan statistic that tests the validity of all instruments. Using the lagged levels dated $t - 2$ and earlier as instruments for the equation in first differences, we obtain consistent and efficient parameter estimates.

The results of the corresponding error correction regressions are summarized in table 5. Tables A2 to A7 in appendix 2 give the complete picture. They include the coefficients of the regression, the summation of the short-run and the long-run effect with the corresponding Wald test p-values, the Sargan test and the M1 and M2 test for the regressions. Tables A2 and A3 explore the dynamics between income growth and changes in inequality, tables A4 and A5 investigate the relations between income growth and changes in poverty and tables A6 and A7 reflect the dynamics of changes in inequality and changes in poverty. The tables include the pairwise relationship of two variables so the first output table contains the results with reference to equation (11) whereas the second table is based on equation (12), respectively. The first column show the results for the whole panel of 114 developing countries, while the other six columns show the results for the regional subpanels.

To verify GMM consistency, we have to make sure that the instruments are valid. We use the Sargan test of over-identifying restrictions to test the validity of the instrumental variables, which is a general specification test. The hypothesis assumes that the orthogonality conditions of the instrumental variables are satisfied. In the case of the Difference estimator the test indicates that the instruments, as expected, do not correlate with the error term in most of the cases. To check the validity of the System GMM estimator the validity of lagged levels combined with lagged first differences should be considered. In these cases the p-values show less satisfactory results, while the Difference Sargan test, which considers only the additionally used instruments for the System equation, returns insufficient results as well. For this reason we only present the results of the Difference GMM estimator.

The coefficients of the error correction term give the adjustment rate at which short-run dynamics converge to the long-run equilibrium relationship. Generally, except for one value all these coefficients are negative and highly significant as expected, so the results show that there exist long-run relationships and provide evidence of a cointegration relationship between all pairs of variables.

The short-run effect can be divided into the effect of the lagged dependent variable and that of the independent variable. The short-time adjustment of the independent variable is measured by the effect of the contemporaneous and lagged change of the independent variable. The significance of the summarized short-run effects, which is simply the sum of the two coefficient values, is tested via a Wald test. The long-run coefficients indicate the long-run elasticities of the independent on the dependent variable. They are computed by subtracting the ratio of the coefficient of the scale effect (lag of independent variable) from the coefficient of the error correction term; again a Wald test proves the significance of the effect.

In table 5 the short-run and long-run dynamic results are characterized pairwise:

[here insert **Table 5**: Summary of the estimated error correction models: long-run and short-run dynamics]

1. With regard to the relationship between *income growth* and changes in *inequality* presented in table 5 (table A2 and A3 in Appendix 2), the results

of the short-run effect indicate a positive significant causal effect from changes in inequality on growth and vice versa for the aggregate panel and several subpanels. With reference to the theoretical model where income growth and inequality is connected through two common factors, $k$ and $A$ and two possible directions of the relationship the empirical results suggest that the accumulative factor is dominant, indicating that these economies are still in the early stages of development when the capital intensifying process can be expected to be strong and high income growth and increasing inequality seems to be the most likely pattern. With respect to the Kuznets relation this also suggests that these countries are situated in the first stage of the Kuznets curve, where inequality increases. Only the subpanel for South Asia exhibits a negative significant effect of growth on inequality, which indicates that the capital intensifying process is less dominant, pushing the economy to the right of the maximum of the Kuznets curve and allowing for decreasing inequality. This confirms the results of the recent panel data studies, based on growth regressions, that there is a positive causal effect between growth and inequality, and that faster growth tends to increase inequality. By contrast, the short-run effect of the lagged first difference of the dependent variable is negative and highly significant related to the simultaneous change of the dependent variable for both income and inequality. The long-run coefficient is significant only in the case of a few subpanels and the effect is positive. The error correction term is always negative and significant. However, as shown in table 5, regions with a lower income and higher poverty, namely South Asia, Sub-Saharan Africa and East Asia and Pacific exhibit a faster speed of short-run growth adjustment, while the adjustment of inequality is slower compared to the regions with higher income.

2. Concerning the dynamics between *income growth* and changes in *poverty* presented in table 5 (table A4 and A5 in Appendix 2), the results show a clear negative short-run and long-run relationship between these variables. Nearly all parameter coefficients of the regressions of the aggregate panel and the subpanels show a negative effect on the 1% significance level. This result corresponds to the theoretical consideration that technology growth improves productivity, so an increasing number of people can cross the poverty line. At the same time technological growth is a general driver of per capita income growth. Therefore, $A$ links income growth and poverty reduction. The results also reveal that there is bidirectional causality between growth and changes in poverty, indicating that higher growth reduces poverty and vice versa, although the long-run effect is only half as strong as the short-run effect. Consequently it becomes apparent that the growth process raises not only the mean income of the country but also the income of the poor and lifts a section of the poor population above the poverty line. Furthermore, it is evident that in poorer regions poverty has a stronger effect on growth, yet growth has a weaker effect on poverty compared with the richer subpanels. This indicates that the

level of development impacts on the poverty-reducing effect of growth. Income growth has benefited the poor regions far less. On the other hand poverty decelerates income growth much more slowly in countries with higher average income. So altogether the positive effect of growth on poverty increases with average income and the negative effect of poverty on growth diminishes with average income. However, it must be pointed out that here, we measure poverty using an absolute poverty line, so we account only for the section of the population that moves from one side of the poverty line to the other. We have no information about the redistribution effect of growth below and above the poverty line. The short-run effect of the lagged first difference of the dependent variable is again negative and highly significant related to the contemporaneous change of the dependent variable for both directions.

3. Finally, table 5 (table A6 and A7 in Appendix 2) present the relationship between changes in *inequality* and changes in *poverty*. The long-run effect is positive and significant in both cases; however the short-run effect is only significant and positive when poverty is the dependent variable. Also, some of the subpanels exhibit a positive short-run and/or long-run effect. In summary the results suggest a positive causal effect of poverty on inequality and vice versa, confirming recent literature which suggests that poverty reduction depends strongly on the degree of inequality and that growth reduces poverty more efficiently in more egalitarian countries. Hence poverty reduction is a determined by growth, income distribution and the change in distribution. Finally, the short-run effect of the lagged dependent variable is again significantly negative, as expected. These results are also in line with the theory where technology growth is expected to improve productivity of labor, so that higher labor productivity leads to a less unequal income distribution. At the same time an increasing number of people can rise above the poverty line. Therefore, $A$ links decreasing inequality and poverty reduction.

In summary, the results of the study show that all pairs of variables exhibit a causal relationship in both directions and that growth, distribution and poverty reduction are strongly inter-related, so to achieve the goal of rapidly reducing poverty requires country-specific combinations of growth and redistribution policies.

# 4 Summary and conclusion

Growth, inequality, and poverty are central elements for evaluating development. After reviewing the current literature we recall some fundamental theoretical relations between growth, income inequality and poverty. In the empirical section we check the stationarity of the data using two common panel unit root tests, the IPS test by Im, Pesaran and Shin (2003) and the Fisher-type test by Maddala and Wu (1999) and Choi (2001). Pairwise cointegration is tested using the panel cointegration test developed by Pedroni (1999, 2004). This test allows for heterogeneity in the panel by permtting heterogenous slope coefficients, fixed effects and individual specific deterministic trends. In a further step the causality relations are analyzed by applying GMM techniques to an error correction model (ECM) to estimate the pairwise short-run and long-run dynamics for income growth and changes in inequality and poverty. The analysis is based on the World Bank´s PovcalNet database. This database, the result of the work of Chen and Ravallion (2007), includes data on income and poverty and inequality measures for a large number of developing countries. Our analysis uses a balanced panel of 114 countries for the period 1981-2005 at 3-yearly intervals; also the panel is split into six subpanels, namely East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, South Asia, and Sub-Saharan Africa. The results of the error correction regressions confirm the theoretical model and show that all pairs of variables exhibit a causal relationship in both directions and that growth, distribution and poverty reduction are strongly inter-related. While growth and inequality exhibit a positive bidirectional causal effect, the relationship between growth and poverty is negative, indicating that growth indeed reduces poverty. Yet the results also show that the level of development affects the poverty-reducing effect of growth. Income growth has benefited the poor regions far less. Furthermore there appears to be a positive causality between inequality and poverty, suggesting that a successful poverty reduction strategy requires both economic growth and a sound redistribution policy.

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# 5 Appendix

### Appendix 1

The countries included in the analysis are:

**East Asia and Pacific:**

Cambodia, China-Rural, China-Urban, Indonesia-Rural, Indonesia-Urban, Lao PDR, Malaysia, Mongolia, Papua New Guinea, Philippines, Thailand, Timor-Leste, Vietnam

**Europe and Central Asia:**

Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russian Federation, Slovak Republic, Slovenia, Tajikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan

**Latin America and the Caribbean:**

Argentina, Bolivia, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Panama, Paraguay, Peru, St. Lucia, Trinidad and Tobago, Uruguay, Venezuela,

**Middle East and North Africa:**

Algeria, Djibouti, Egypt, Arab Rep., Iran, Islamic Rep., Jordan, Morocco, Tunisia, Yemen

**South Asia:**

Bangladesh, Bhutan, India-Rural, India-Urban, Pakistan, Sri Lanka

**Sub-Saharan Africa:**

Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Dem. Rep., Congo, Côte d'Ivoire, Ethiopia, Gabon, Gambia, Ghana, Guinea-Bissau, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Togo, Uganda, Zambia

[here insert **Table A1:** Correlation Matrix]

[here insert **Figure A1:** Growth and change in inequality]

[here insert **Figure A2:** Growth and change in poverty]

[here insert **Figure A3:** Change in inequality and change in poverty]

**Appendix 2**

Estimation results are given in the following tables A2 to A7:

[here insert **Table A2**: Estimated error correction model: long-run and short-run dynamics of growth and changes in inequality]

[here insert **Table A3**: Estimated error correction model: long-run and short-run dynamics of changes in inequality and growth]

[here insert **Table A4**: Estimated error correction model: long-run and short-run dynamics of growth and changes in poverty]

[here insert **Table A5**: Estimated error correction model: long-run and short-run dynamics of changes in poverty and growth]

[here insert **Table A6**: Estimated error correction model: long-run and short-run dynamics of changes in poverty and changes in inequality]

[here insert **Table A7**: Estimated error correction model: long-run and short-run dynamics of changes in inequality and changes in poverty]

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