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Worker remittances, migration, accumulation and growth in poor developing countries

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Abstract. The impact of migration and worker remittances on literacy, accumulation of capital and growth is analyzed for a panel of countries with per capita income below $1200 (2000). We estimate regressions for dynamic equations of migration, worker remittances, savings, investment, tax revenues, public expenditure on education, interest rates, literacy, labour force growth, development aid and GDP per capita growth, using dynamic panel data methods. The estimated equations are then integrated to a dynamic system that allows for simulations using the whole integrated system allowing conceptually for the open economy aspects aid, trade, capital movements and migration. The linear-quadratic impact of the income difference between rich and poor countries on remittances and migration generates some highly non-linear results in the baseline simulation. Then we analyze the counterfactuals 'remittances send only 50%' or 'no net migration'. The results for the direct effects are that emigration lowers savings and labour force growth. The total effect of net migration on GDP per capita is to increase the growth rate until 2150 and the effect on levels runs up to 7% above the baseline value. Remittances enhance savings, public expenditures on education and growth, but reduce tax revenues and emigration. These latter two effects, however, are outweighed by the indirect effect of remittances on savings, which have a strongly positive impact on tax revenues and emigration, indicating that conclusions from single equation regressions maybe misleading and indirect effects may dominate for some variables or strongly reduce the direct effects. The total effect of remittances on levels and growth rates of GDP per capita, investment and literacy are positive.
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1. Introduction

Recent empirical papers have obtained very different results regarding the impact of worker remittances on growth. There are studies for many countries and studies for single countries or small groups of countries. In studies for many countries Chami et al. (2005) have argued that remittances provide an incentive to reduce effort and thereby make weak economic performances more likely. They find negative impacts of remittances on growth. In Lucas (2005) and IMF (2005) this result is attributed to weak or inadequate instruments and in the latter no growth effects are found. Catrinescu et al. (2006) extend the approach of Chami et al. to include policy and institutional variables and estimate a panel using the Anderson-Hsiao estimator. They find some significantly positive results for the impact of remittances on growth, but these are not very robust. Giuliano and Ruiz-Arranz (2005) add remittances multiplied to financial variables and find positive growth effects for financially less developed countries. Ramirez and Sharma (2008) have confirmed this result for 23 Latin American countries.

In studies for small numbers of countries the evidence is mixed as well. Glytsos (2005) estimates the impact of remittances on consumption, investment, output and imports for five countries in a traditional, dynamic Keynesian model. He finds long term multipliers of (on average) 2.3 for income (and .6 for investment). The paper is rich in discussing the related ups and downs of remittances and other variables, but it does not consider the impact of remittances on human capital. Solimano (2003) has included remittances in a time-series growth regression for Colombia and Ecuador finding positive signs for both, which is insignificant though for Ecuador. The regression does not include a labour growth variable as a control. Mundaca (2005) adds remittances to a growth regression for Mexico and the Dominican Republic that contains the standard deviation of GDP per capita growth and domestic bank credit as regressors and finds a positive effect of remittances on growth, which is higher than without the credit variable. She interprets this as a higher impact of remittances in the presence of better financial development, because remittances are better channeled to their purposes. Burgess and Haksar (2005) find inconclusive evidence for the effect of the growth of remittances on the growth of GDP per capita for the Philippines. Cáceres and Saca (2006) report a negative impact of remittances on economic activity. It is unclear though in how far this is caused by remittances or rather by policies accompanying the inflows with the intention to correct expected negative effects. Acosta et al. (2007) report positive impacts of remittances on growth for countries in Latin America and the Carribean. However, the initial value of the GDP per capita has the wrong sign, which may signal heterogeneity in the panel in regard to convergence.

All of the literature mentioned above analyzes the direct effects of remittances on growth, given the effects of investment, population growth and other variables on growth. In this paper we want to analyze also the indirect effects of remittances and migration on the growth of GDP per capita and other variables. We do this for a panel of poor countries whose growth rates have been around 1.3% in the 1960s and 1970s, negative in the 1980s but above 2% since 1995. We choose countries with per capita income below 1200 US dollars as of the year 2000, because we found in earlier work that these countries are poor exactly because they had low growth rates, although this was and is different for some of them during sub periods.

The model dealing with this consists of eleven equations explaining remittances, savings, investments, public expenditure on education, official development aid, tax revenues – all as a share of GDP - , net immigration as a share of the labour force, literacy, labour force growth, GDP per capita levels or growth rates, and interest rates. For some of these variables regressions are available in the literature. We adjust them for our purpose to include remittances, migration and aid. For other variables we run new regressions. To complete the model we add three equations for the OECD growth, US interest rates and the growth of world GDP.

We use data from the World Development Indicators for countries, which have at least one dollar of remittances in recent years, receive development aid and have data on literacy and GDP per capita. These are 52 countries below 1200 dollar in prices as of the year 2000. This borderline has been found by estimating kernel density functions, which have a peak at about $1000 for many decennia indicating very slow growth before 1995. Then, $1200 is a natural seizure because between this value and $1500 there is only a very low number of countries, and countries above this value are known to have higher growth.

In section 2 we set up a model that explains our line of thought on how remittances and migration have an impact on growth. In section 3 the data and the econometric method are explained. Section 4 explains the results of the estimates. Section 5 presents the simulations of the dynamic model. Section 6 compares the long run simulation to its counterfactuals of (i) putting remittances to 50% of their simulated values and (ii) of setting net migration equal to zero – the mirror image of countries of destination closing their borders - thereby allowing only as many people to immigrate as there are emigrants including return migrants. Section 7 summarizes and concludes.

2. The Model

In this section we explain the regressions in detail. We estimate them separately and put them together for simulation in section 5. We present the regressions including regressors that may turn out to be insignificant. Added quadratic terms or other variants of the same regressor and the use of lags including polynomial distributed lags will mostly be presented only in section 4 when presenting the result.

The starting point of the model is the growth regression. Equation (1) endogenizes the growth rate.

$$\log(gdppc)-\log(gdppc(-5)) = c_{11} + c_{12}\log(gdppc(-5)) + c_{13}\log(gfcfgdp(-x)) + c_{14}lit + c_{15}d(\log(l)) + c_{16}wr/gdp + c_{17}oda/gdp + c_{18}time + c_{19}(\log(wld)-\log(l)) + \text{lag. dep. variables} + u_{1(it)} \quad (1)$$

We use five-year intervals for the lagged dependent variable here for three reasons. First, we do want to get rid of business cycle effects, which would be captured by one-year lags. Second, we do not want to apply the method of using five-year averages for reasons discussed extensively in Loayza et al. (2000) and Attanasio et al. (2000). Third, lagged dependent variables with a five-year lag are less strongly correlated with other regressors reducing the danger from multicollinearity. In regard to the investment as a share of GDP variable Attanasio et al. (2000) have pointed out that growth regressions tend to use the investment data over the same period as the dependent variable whereas vector-autoregressive approaches use lagged investment and both get opposite signs. As the authors point out, this is hard to explain. We try both, current and lagged investments because there is no guarantee that investment is productive only after a whole year. Then, in a hypothetical steady state both could have equal values and might have the same role as the savings ratio in a Solow or Cass-Koopmans growth model if the difference of their coefficients is positive. They can differ, however, outside the steady state. In fact though, the non-linear impact of the income difference between poor and OECD countries in the equations for migration and remittances make it impossible to have a steady state.[1] The literacy variable proxies for human capital but it will have no direct impact in this poor country sample. Moreover, the growth rate of employment, approximated here by that of the labour force, has a negative impact on the transitional growth rate and the steady-state level of GDP per capita. Remittances are also included because they may have direct effects via effort as in Chami et al. (2005) or via credit market effects as in the literature discussed above or via

[1] On the relevance of non-linearities in growth regressions for other variables see Minier (2007).

sectoral allocation effects as in Feder (1983).[2] Development aid may have a positive growth effect if used to improve allocation and effort or it may have a negative effect if it makes them worse. In particular, if aid is directed towards emergency action, fighting diseases and poverty reduction one might expect that this strengthens sectors with productivity growth below the multi-sector average. Depending on whether or not the time trend is significant we would have permanent or only transitional growth. In models with imported inputs (see Bardhan and Lewis 1970) one finds also the growth rate of exports at constant terms of trade, which should be an income growth term in an export demand function, and therefore is approximated here by the growth rate of the world GDP. Constant long-run growth in the world economy or by the OECD allows for positive permanent growth in this model. Exports and this latter growth rate have to be taken relative to the size of the labour force though. Therefore we include the natural logarithm of the labour force here as well.[3] Finally, we will add some lagged dependent variables as an autocorrelation correction hoping that this absorbs the business cycle effects and allows interpreting the other regressors as growth effects.[4]

But remittances and aid do not only have a direct impact on growth but also an indirect one via fixed capital formation, the enhancement of savings, reduction of net debt flows and reduction of interest rates if investment is interest elastic, and on literacy via savings and public expenditure on education, as well as on labour force growth via migration (directly and via savings) and literacy, and from the direct effect on GDP per capita growth to labour force growth.[5] These indirect channels are considered next.

The equation explaining worker remittances as a percentage of GDP is the logical next point. This is formulated in equation (2).

$$wr/gdp = c_{21}+c_{22}wr(-1)/gdp(-1)+c_{23}\log(OEC) + c_{24}(\log(gdppc(-x)) + c_{25}\log(1+ri(-2)) + c_{26}\log(1+rius(-1)) + c_{27}time + c_{28}peegdp(-x) + c_{29}NM(-x)/L(-x) + u_{2(it)} \quad (2)$$

Remittances as a share of GDP, *wr/gdp*, are explained by an equation similar to that of Chami et al. (2005) and others earlier[6] containing the differences of income and interest rates of the recipient and the sender country. Therefore we include the income of the recipient country. The

[2] See also Rodriguez 2006. For references to single-country studies of the effects of remittances see Taylor 1999, p.70 and Ramirez and Sharma (2008).
[3] We will discuss the plausibility for the steady state results quantitatively below.
[4] The ideal response to serial correlation in growth regressions is probably to merge models of growth and cycles. The fact that some exists does not automatically mean that serial correlation vanishes, because the integration is mostly based on one aspect only, such as stochastic technical progress. However, the serial correlation may have other causes such as changing situations of too optimistic and too pessimistic expectations. Therefore we work with the traditional serial correlation correction of adding (growth rates of) lagged dependent variables.
[5] An early contribution to the relation between literacy and growth is Azariadis and Drazen (1990).
[6] See also El-Sakka and McNabb (1999) and the references there.

sender knows his own current income. As most of the migrants go to the OECD countries we represent his income by per capita income of the OECD, *OEC*.[7] The sender will have information on the recipient country only from data about earlier years because it takes about one year or more in many countries to make the data. An indicator of the recipients' income is therefore Gross Domestic Product per capita with some lags, *gdppc(-x)*. The two income variables need not have the same coefficient because the OECD income is only a crude proxy that comes in because we use only one indicator for the host country of the senders. We do not use the Gross National Income as senders are more likely to receive information on GDP then those of GNI through the media. Moreover, the effect of capital income may be captured by the interest rate arguments included and explained below. The sender might consider saving the amount of money rather than transferring it. Therefore we use the real interest rate of the USA, *rius*, as an indicator of these opportunity costs, also because we don't have an interest rate for the OECD. On the other hand the sender might consider putting the money into a bank account in the recipient country. Therefore we also include the real interest rate of the recipient country, *ri,* also with some information lag. Next, remittances are assumed to depend on (a polynomial of) their own past value, a constant and a time trend, which will be dropped if insignificant. As real interest rates can be highly negative we add a value of 1 to it, before taking natural logarithms, because we use interest rates in their scientific notation, that is, 5% is indicated by '0.05'. Essentially equation (2) above is the one that appears also in Chami et al. (2005).[8] Using natural logs for the remittance variable gives slightly worse results. An important variable related to the focus on market imperfections of modern migration theory is public expenditure on education as a share of GDP, *peegdp*, which indicates that migrants may send more money if the government spends less on education. If this is the case for current and lagged values then we would think of a structural relation indicating an investment motive. If, however, this occurs only when *peegdp* is currently low but not for lagged values we would interpret remittances as private emergency aid making sure that schooling plans can be realized in times of budget cuts. Finally, past migration may have an impact on remittances. However, we do not have stock data in panel format and it is far from clear whether or not net migration flows, which are available, will have a significant impact. The first index of each coefficient indicates the number of the equation and the second that of the regressor. Further below we will provide equations explaining the dynamics of the interest rates and public expenditure of education as a share of

[7] Niimi and Özden (2006) provide some evidence that migration to Gulf countries does not yield different results than to the OECD in explaining remittances flows.

[8] Chami et al. (2005) use the real income of the USA instead of that of the OECD. The correlation of these two series is gdppcusa = 3071+ 1.12oec with an adjusted R-square of .99 and t-values 116 and 885 respectively. It should not matter which of these is used.

GDP. The US interest rate and the GDP per capita of the OECD will not be determined in the model but will be considered to be autoregressive processes.[9] We add residuals, *u*, whose first index is that of the equation and the second refers to the observation of country *i* at point in time *t*.[10]

The next step is to explain the impact of worker remittances on savings in equation (3).

$$savgdp = c_{31} + c_{32}savgdp(-1) + c_{33}(wr/gdp) + c_{34}d(\log(gdppc)) + c_{35}\log(1+ri(-1)) + c_{36}(oda/gdp) + c_{37}peegdp + c_{38}NM/L + u_{3(it)} \quad (3)$$

Remittances and migration are added to an equation explaining the savings ratio similar to that in Loayza et al. (2000). Basically, we assume that the savings ratio, *savgdp*, is driven by its own past value and, as in most of the literature (see Loayza et al. 2000, Table 1), by the growth of GDP per capita and by real interest rates. As disposable income is conceptually probably a better variable (see Bertoli 2006, eq. (6)) but also less available in terms of data we may add worker remittances to the regression, which are part of disposable income but not part of GDP. The idea here is that higher disposable income and therefore remittances lead to a higher savings ratio as in theoretical models using the difference of consumption and an existence minimum for consumption in the utility function when the country in question is close to that minimum. This is quite plausible here because remittances reduce poverty (see Adams and Page 2005).[11] Moreover, we add official development aid to the regression because aid is also an international transfer and might be significant according to the single-equation-estimation literature (see Doucouliagos and Paldam 2006). Again related to market imperfections, people may want to save less if the government takes over the cost of schooling through higher public expenditure on education as a share of GDP. Finally, immigrants bring savings with them and emigrants take savings out of the country. These savings of migrants may be higher (for relatively rich migrants) or lower (for relatively poor migrants) than the domestic rate and therefore may have an impact on the savings rate, in particular if migrant get work only with some delay but bring their savings into the country without delay.

[9] This follows from using them together with world GDP in a VAR (vector autoregressive regression) model, choosing optimal lag length, checking stability, and estimating an error–correction model. The Boswijk t-values for the adjustment coefficients indicate that the GDP per capita of the OECD and the US interest rate are not endogenous.

[10] Using other regressors leads to different endogeneity problems than those discussed below. They are discussed by Niimi and Özden (2006) in connection with a cross-country regression. For example, the income per capita of sender and destination countries used in this paper would also explain the number of migrants, which are a major determinant in their regression as they are in our migration regression below. The authors do not discuss the paper by Chami et al. (2005). But they have interesting results in regard to the dis-aggregation with respect to education. Data for stocks of numbers of migrants are available only for 1990 and 2000 in Docquier and Marfouk (2006). Therefore we can't use them for our dynamic analysis, which is the essence of growth simulations and the counterfactuals analyses in the following sections.

[11] Another plausible consequence of the impact of remittances on savings is their impact on stock market development (see Billmeier and Massa 2007).

If remittances enhance savings they should diminish the difference of investment and savings, which is the additional demand or flow variable of foreign debt, which in turn reduces domestic interest rates as found by Obstfeld and Rogoff (2001) from a two period model with transport costs without the other variables included here. Other possible rationales for this aspect of modeling interest increases are as follows. In Bardhan (1967) and later publications on growth under capital movements by others one finds the assumption that large countries may have an impact on the world market interest rate and therefore on there own interest rate through a lower or higher stock of net debt per unit of GDP. If so, this should also hold for the flow of net debt. It is questionable though whether single countries involved have monopsony power. But they may have this as a group if their behaviour goes into the same direction. Moreover, it is plausible to relate domestic interest rates to the LIBOR/EURIBOR or Prime Rate plus a country specific spread or risk premium. Edwards (1984) has shown that spreads depend on the ratio of debt to GDP or GNI. This ratio is lower one period after investment net of savings has grown by less than the GDP. Banks and rating agencies then can verify that less new debt relative to GDP is incurred and may reduce spreads. Therefore we use the sum of lagged current account deficits or investment minus savings. Belloc and Gandolfo (2005) argue that this relation may be non-linear based on data analysis. Therefore we include a polynomial distributed lag of the investment-savings difference.

$$\log(1+ri) = c_{41} + c_{42}\log(1+ri(-1)) + c_{43}\log(1+riusa) + \text{sum}_x c_{4x}(invgdp(-x)-savgdp(-x)) + c_{45}(oda/gdp) + c_{46}d(\log(gdppc)) + u_{4(it)} \quad (4)$$

Moreover, the US interest rate, and the growth rate of the GDP per capita are included because they both enhance the domestic rate with the latter being a business cycle effect. Finally, more development aid implies more political dependence and signals risk of a lower power for debt service.

If remittances, via enhanced savings and lower net debt demand, reduce interest rates, the link to physical capital is gross fixed capital formation as a share of GDP, *gfcfgdp*, if investment is elastic with respect to interest. This is captured as in equation (5).

$$\log(gfcfgdp) = c_{51} + c_{52}\log(gfcfgdp(-1)) + c_{53}\log(1+ri(-1)) + c_{54}d(\log(gdppc(-1))) + c_{55}wr/gdp + c_{56}((oda/gdp)) + c_{57}d(\log(L)) + c_{58}d(lit) + u_{5(it)} \quad (5)$$

Gross fixed capital formation as a share of GDP is assumed to depend on its own lagged value, interest rates and lagged growth rates as an indicator of the business cycle and of expectations of future demand and the future need for investment. The domestic interest rate indicates (opportunity) costs. The lag in the interest rate variable indicates that it takes time to get the

information on interest, order and deliver machines, and implement them. Moreover, as in the savings equation we add official development aid. Remittances may have a higher marginal propensity to invest than average income (growth) if the migrants are from relatively rich families and migrate in order to earn the money they can't get from imperfect capital markets. Vargas-Silva (2007) finds a positive impact of remittances on investment for Mexico. This should not be the case if credit were freely available. However, firms and in particular household producers may be credit rationed. Poorer households are more subject to credit rationing (see IMF 2005, p.77 and Adams 2006). Then their investment may not exceed their savings. With investment limited by savings for sufficiently many households, investment may have the same sign for the interest rate variable as savings, and remittances and aid may relax the credit constraint and therefore be significant variables, although the economy has some capital inflows from abroad. For development aid, in addition, donors can try to enforce by tying to imports from donor countries or through the World Banks Oil-and-dams program that aid is invested[12]. Investors can try to use the fungibility of money to leave investment unchanged by shifting their own money elsewhere. If the coefficient of aid is significant this would also imply that the fungibility of money does not lead to a withdrawal of domestic money at an equal amount. Finally, we add employment growth proxied by labour force growth and changes of literacy. In accordance with production theory a higher input of more or less skilled labour increases the marginal product of capital and makes more investment profitable. If savings and investment are interest inelastic the effect of increased savings will still be one of reducing debt service, new debt and the future interest paid on it.

Besides the impact of remittances on physical investment and savings and interest rates, remittances may complement public expenditure on education in financing schooling, directly or via savings. However, it may also be the case that governments provide less money for education if people have more private money from remittances. The equation for this political behaviour is as follows:

$$Peegdp = c_{61} + c_{62}peegdp(-1) + c_{63}taxy + c_{64}oda/gdp + c_{65}wr/gdp + c_{66}savgdp + c_{67}time + u_{6(it)} \quad (6)$$

Public expenditure on education is then used together with savings and aid to finance schooling. This results in higher literacy, which is captured in equation (7).

$$lit - lit(-5) = c_{71} + c_{72}lit(-5) + c_{73}savgdp(-x) + c_{74}oda/gdp + c_{75}peegdp(-x) + u_{7(it)} \quad (7)$$

[12] This does not necessarily mean that the type of investment or even the enhancement of it is efficient.

Savings available at the moment of enrolment can be used to avoid credit constraints. A higher savings ratio together with higher public expenditure on education and development aid leads to higher literacy with some lags. By implication, the concept is that remittances have an impact on human capital via savings with remittances and savings entering the equation for public expenditure on education and savings and public expenditure on education entering the literacy equation (see also the theory of Cinar and Docquier 2004 and Bertoli (2006)).[13] Literacy data are used as a proxy for human capital. They have a good variation in our sample over time and across countries.

As public expenditures on education are dependent on tax money we explain it next.

$$taxy = c_{81} + c_{82}\, taxy\,(-1) + c_{83}\, wr/gdp + c_{84} savgdp + u_{8(it)} \qquad (8)$$

Tax revenues as a share of GDP are assumed to depend on their own past value. If people save more they signal that they have a surplus product and therefore might be willing and/or able to contribute to public investment as well. More worker remittances then may be an argument to tax people more or less heavily. On the one hand there is more money available that can be taxed. On the other hand the government may want to tax less as people can care better for themselves if they have more money and the government may want to withdraw.

Official development aid helps financing literacy directly and indirectly by providing an incentive for more public expenditure on education in equations (6) and (7). We explain it by the lagged growth rate of the receiving country and that of the donor countries, captured by that of the OECD. If economies grow more quickly, they are likely to receive less aid over time and if donors growth more quickly they may be more generous.[14]

$$oda/gdp = c_{91} + c_{92} oda(-1)/gdp(-1) + c_{93} d(\log(gdppc(-x))) + c_{94} d(\log(oec(-x))) + u_{9(it)} \qquad (9)$$

[13] Mazumdar (2005) has suggested public expenditure on education as a share of GDP. It is insignificant in his cross-country regressions but significant in our fixed effects estimate with lagged dependent variables presented below, which suggests that there is a dynamic impact.

[14] It is not the purpose of this paper to go deeply into other motivations for and impacts on aid.

Next, we need an equation for the growth of the labour force. According to growth theory and empirics, a major contribution to growth may come from the reduction of population growth. However, in empirical work the crucial variable is equilibrium employment growth - proxied here by labour force growth rates -, because one of the growth problems is to have sufficient investment to employ people without falling wages and incomes. Labour growth is preceded by population growth. The literature there says that education of women leads to a slow down. Therefore we include literacy with a large lag. Labour market literature says that higher growth encourages people to (re-)enter the labour market. This suggests including the growth rate of GDP per capita. Development aid may encourage people not to go to work but rather to education or other (in-)activities and to return to the labour market later or they may save lives and thereby increase labour supply sooner or later. Moreover, immigration adds partly to the labour force. We endogenize labour force growth as follows.

$$d(\log(l)) = c_{10,1} + c_{10,2}d(\log(l(-1))) + c_{10,3}lit(-x) + c_{10,4}oda(-x)/gdp(-x) + c_{10,5}nm/l + c_{10,6}d(\log(gdppc(-1))) + u_{10(it)} \quad (10)$$

As immigration has an impact on labour force growth according to the previous equation and on savings according to other equations we need an equation for them to have all variables endogenous in the system. The traditional argument is that of an expected income difference between origin and destination countries. In poor countries people are unlikely to bear the costs of migration out of current income and will need to increase their savings, if they are credit rationed, before migrating later. If they receive remittances they can use them either to pay for emigration or to invest them and stay, in particular if capital markets provide credit for small business only imperfectly. Therefore remittances have also a partial, direct effect of slowing down growth by enhancing immigration and labour force growth. Lagged dependent variables may reflect network effects.[15] The specification then is as follows.

$$nm/l = c_{11,1} + c_{11,2}nm(-5)/l(-5) + c_{11,3}(\log(gdppc)-\log(oec)) + c_{11,4}\, wr/gdp + c_{11,5}\, savgdp(-x) + u_{11(it)} \quad (11)$$

After remittances enhanced savings and thereby literacy, literacy enhances investment shares and reduces labour force growth, which in turn reduces investment shares. Both labour force

[15] For an extensive discussion of international migration theories see Massey et al. (1993).

growth and investment have an impact on transitional growth rates and the level of per capita income captured in equation (1). Another important economic mechanism is the effect of remittances directly and indirectly via savings on migration in equation (11) and from there to labour growth in equation (10). The link from migration to labour force growth and from there to growth is a strong feedback effect in our model. As remittances have an impact on savings and both affect literacy and migration and from there the labour force growth, it is this type of loops which makes a dynamic system very interesting - as noted earlier by Lucas (2005) - in particular in connection with non-linear effects obtained in the estimates below.

In order to run simulations with the estimated dynamic model, we also need some auxiliary equations for those variables, which do not appear on the left-hand side of equations (1)-(11). In dynamic stochastic general equilibrium models (DSGE) these are run just as autoregressive processes. We will try to elaborate them a bit more than that, but the model should not get much larger. Therefore we limit the regressors for these equations to those which are already in the model and therefore leaving out some of the arguments of the more specialized literature on these issues. We need an equation for the interest rate of the USA, for the growth of the GDP per capita in the OECD and for the growth of the GDP of the World. We will explore the interactions among these variables from the perspective of vector-autoregressive (VAR) and error-correction models (ECM) in order to clarify the endogeneity relations among them and present them in section for as results only.

3. Data and econometric method

All data are taken from the WDI (World Development Indicators). We include 52 countries (listed in Appendix 1) selected by the criterion of having at least one dollar of remittances received in one of the recent years, receive development aid and have data for literacy and GDP. We include countries under (constant 2000) $1200 GDP per capita. The reason is that we found in earlier work that the countries below $1200 have slow growth in a panel average when looking at the period 1960 to 2003. The richer countries tend to have a relatively good growth performance anyway. Poor countries may behave differently from the richer ones and therefore we concentrate on those for whom remittances and aid are more important.

The data on remittances are official receipts in constant 2000 US$.[16] Flows going via financial investments and withdrawals from related accounts are not included (see IMF 2005, p.99). Unofficial receipts may be high - Freund and Spatafora (2005)

[16] In the WDI there are surprisingly many zero values, which are quite implausible because they are preceded and followed by positive values of non-negligible size. We have turned them into ‘non available’.

estimate that informal remittances are between 35 and 75% of the official ones - and important but we have no way to deal with the issue directly (see Adams and Page 2005).[17] Data of the GDP per capita, *gdppc* and *OEC* are in constant 2000 US$ and stem from national accounts. We would like to point out that not only remittance data but also GDP data underestimate economic activity because of the neglect of the informal sector. Schneider and Enste (2000, Table 2) report values of 25-76% of GDP for developing countries. This is the same order of magnitude as cited above for remittances. For developed countries these values are lower. The imperfection of remittances data is broadly discussed in all related papers. That of GDP data is not discussed anymore although it may be as severe. It is often stated that remittances are larger than aid for all developing countries together. In our sample though, aid is about 9.5% of GDP, more than three times as much as remittances.

Interest rates, *ri* and *rius*, are real rates as obtained by use of the GDP deflator and taken from the IMF IFS Yearbook into the WDI data. Savings, *savgdp,* are gross national savings from national accounts, calculated as GDP minus consumption, plus net current transfers and factor income from abroad and expressed as a share of GDP.[18] As investment, *invgdp*, relates to the demand of net debt flows we use gross capital formation (formerly called gross domestic investment) as a percent of GDP. The major difference with gross fixed capital formation as a share of GDP, *gfcfgdp*, is the inventories, which are not investments that add to the capital stock. All savings and investment data come from the national accounts. Literacy data, *lit*, from the UNESCO are available in the WDI. Data on public expenditure on education, *peegdp*, are from the UNESCO and we take those of several versions of the World Development Indicators. Data on official development aid include loans containing at least a grant element of 25%. Data on migration are five-year estimates of the United Nations Population Division. Labour force data are from the ILO.

The average values and growth rates of these data are presented in Table 1. These data show positive growth rates of GDP per capita. Investment/GDP and savings/GDP ratios have positive growth rates for these poor countries. Investment/GDP ratios are higher than savings/GDP ratios inducing higher indebtedness. Average remittances per unit of GDP are 2.9% and growing at a rate of more than 6%.

[17] Panel data on remittance fees, which cause unofficial receipts, would be an interesting addition here. But we are not aware of their availability.

[18] Using savings as share of GNI does not change regression results here. As we need investment as a share of GDP in the growth regression, we use also savings as a share of GDP.

TABLE 1 OVER HERE

We estimate the above mentioned equations separately using dynamic panel data methods. Fixed effects are never redundant and random effects are never outperforming fixed effects. The bias of fixed effects estimates in case of lagged dependent variables is known to be of the order of magnitude *1/T*, where *T* is the number of periods. Fixed effects underestimate in principle, whereas OLS overestimates the coefficient of the lagged dependent variable. According to Judson and Owen (1999) the bias is very small when *T* is above *30*. When *T* is below thirty we should try the GMM-systems estimator of the Arellano-Bover (1995) method as explained in Chapter 8 of Baltagi (2005). The latter method specifies our equations in terms of levels and in terms of first differences and restricts the coefficients of these equations to be the same for identical variables. The use of this method has to result in two properties of an estimator. First, the estimated coefficient should be between those of fixed effects and OLS. Second, the Hansen-Sargan statistic, which is increased through the use of instruments, should not be too high through the over-identifying constraints but rather at its value according to the chi-square distribution but it should also not be too low, because this would indicate that instruments have no effect or too many are used (Roodman 2007). We have tried this for all equations. For the equations for growth, labour force, and migration, both conditions are fulfilled although the difference between fixed effect and Arellano-Bover results are small. But the two criteria are never fulfilled simultaneously for the other equations. In these cases we probably have to live with a bias. The reason probably is that we mostly have close to thirty periods in the observations and then this bias might be very small. Moreover, we have used another advantage of the Arellano-Bover method. We run some regressions also using dynamic instruments for other supposedly endogenous regressors than just the lagged dependent variable (see Appendix 2). Results change only slightly. A disadvantage is that from these estimates we do not obtain the constants of the equations because the orthogonal deviation method of Arellano-Bover for the calculations does not calculate them. Simulations in section 5 therefore have to be based on the first-difference version of the estimates.

The use of the systems GMM method and of fixed effects requires absence of unit roots. Applying standard panel unit root tests would reject the hypothesis for the natural logarithm of the GDP per capita variable. However, in their standardized package version these tests do not take into account other regressors than a fixed effect and an individual specific time trend. Growth regressions though do this. There it is accepted wisdom that in the regression of the growth rate on other variables the lagged level of the GDP per capita has a significantly negative coefficient and by implication no unit root. Therefore systems GMM is often applied to

growth regressions (see Bond et al. 2001 and Giuliano and Ruiz-Arranz (2005). A similar argument can be made for worker remittances as a share of GDP. Standard tests for unit roots show mixed evidence in our sample as in that of Ramirez and Sharma (2008). We assume, as they do, that worker remittances have no unit root. Note that a unit root would imply a constant growth rate which would imply that variables which are shares of GDP exceed unity or go to zero in the long run. Moreover, assuming a unit root below in the regression for remittances and therefore dropping lagged dependent levels results in a strong fall of the adjusted R-squared. For a more exact test we do not have the critical values (corresponding to those in the standard tests) for cases with other regressors rather than fixed effects and individual time trends. There are no strong indications for unit roots for worker remittances as well as for other variables expressed as share of GDP per capita. In the growth regression, the logs of world GDP and the labour force of the country are likely to have unit roots, but they are cointegrated according to the panel cointegration tests by Pedroni (1999), Kao (1999) and Maddala-Wu (1999) and therefore can be used in the regression. Finally, a standard ADF test suggests that US interest rates have unit roots. Where they appear in the equations they are also cointegrated with the income difference of the OECD and the countries in equation (2') below.

4. Estimation results

As the literature has focused mainly on growth regressions we present results for that first. Moreover, these results for remittances will not be dominated by indirect effects when we compare the simulations of the system of all equations with and without remittances.

Growth regressions: The direct effects of remittances and aid.[19]

$$\begin{aligned}\text{LOG(GDPPC)} = c_{1i} &+ \underset{(0.0000)}{0.81}\text{LOG(GDPPC(-5))} + \underset{(0.005)}{0.051}\ \text{LOG(GFCFGDP)} - \underset{(0.015)}{0.327}\ \text{D(LOG(L))} \\ &+ \underset{(0.032)}{0.52}\ \text{WR(-1)/GDP(-1)} \underset{(0.0223)}{-2.44}(\text{WR/GDP})^2 \underset{(0.0025)}{-1.1}\text{ODA/GDP} + \underset{(0.0001)}{0.365}\ \text{ODA(-1)/GDP(-1)} + \underset{(0.0334)}{1.61}(\text{ODA/GDP})^2 \\ &+ \underset{(0.0022)}{0.196}\ \text{LOG(WLD)} \underset{(0.017)}{-0.148}\ \text{LOG(L)} \qquad (1')\end{aligned}$$

Per.: 30 (1976-2005); Countr.: 48; Obs.: 644. S.E.E.: 0.057; J-stat.: 74.7; Instr.rank: 68; p(J): 0.07.[20]

In the relevant range remittances have a positive impact on growth and aid has a negative one. For aid the result is plausible because for poor countries much of the aid serves emergency and poverty alleviation and some parts are just lost in the political and administrative process. These

[19] P-values in paranthesis. (0) means that the p-values is zero at the first five digits. Two lagged dependent growth rates functioning as serial correlation correction are not reported.

[20] This p-value belongs to the Hansen (or Sargan) J-statistic.

effects may bias the sectoral structure towards consumption sectors, which possibly have lower growth than those of exports and investment because they serve relatively more poor people and include agriculture whose growth rate is limited in many poor countries.[21] Aid also weakens democratic institutions (Djankov et al 2008) which may have a negative impact on total factor productivity (Rodriguez 2006). The opposite results for remittances and aid within the group of poor countries is also quite plausible in view of the fact that emergency aid may go predominantly to the poor strata whereas remittances are obtained by those who are able to afford the cost of migration (see IMF, 2005, p.73). The amount of aid then is also an indicator of bad times because of famines, earthquakes, tsunamis et cetera, which may shift the sectoral allocation towards consumption. This is an endogeneity we deal with by use of lagged aid variables as instrument (see Appendix 2). The GDP of the world, included as *log(WLD)*, and the level of the labour force, *log(L)* have coefficients of the same order of magnitude and would be closer to each other if we had the lower employment data.[22] The significant lagged dependent variable is used with a five years lags. Gross fixed capital formation as a share of GDP[23] and labour force growth have the expected sign and are significant. Without the world income variable, a time trend would be significant. The ordinary time trend would be associated with total factor productivity growth, whereas world income is an argument in the export function of models with imported inputs (see Mutz and Ziesemer 2008). With an insignificant time trend, the latter seems to be more relevant than the former in developing countries. The literacy variable is insignificant. If we drop *log(wld)* and *log(l)*, literacy becomes significant. In related work on richer countries we find a significant effect for both, literacy and world income. The reason for the insignificance may be that the countries are specialized in sectors that use predominately unskilled labour, because of the countries' low human capital endowments. Only when low population growth and education for women are sufficiently close to that of richer countries,

[21] For the richer sample used in complementary work we find a significantly positive sign for aid. On the topic of parameter heterogeneity for different samples see Hineline (2008).

[22] The standard steady state assumption from growth theory would be a constant share of all variables which are expressed as a share of GDP. Under these assumptions taking first differences of equation (1') leads to a formula that is familiar from the Bardhan/Lewis model: d(LOG(GDPPC)) = 0.81d(LOG(GDPPC(-5))) + 0.196d(LOG(WLD)) -0.148d(LOG(L)) = 0.81d(LOG(GDPPC(-5))) + 0.196 (d(LOG(WLD))- d(LOG(L)) **-** **(**0.148 -0.196)d(LOG(L)). In terms of steady state growth rates this implies $g_y = 1.03g_w - 0.78g_L$ with g_y as the growth rate of the GDP per capita, g_w that of the GDP of the World, and g_L that of the labour force. Inserting our long run result of 3.1% for World GDP growth we get $g_y = 0.032 - 0.78g_L$. Only at a labour force growth rate of 1.64% will our result for poor countries be equal to 1.924%, that of the OECD. At a labour force growth rate of 1% we get a growth rate of 2.4%. These are quite reasonable results for economies which import their capital goods and therefore are driven by the world income term in their export function (see Mutz and Ziesemer 2008 for a theoretical formulation and estimation of an explicit growth model without linearization).

[23] Current investment and labour force growth may suffer from an endogeneity bias. Using lagged instruments in the Arellano-Bover method and as a cross-check also in two-stage-least squares (TSLS) corrects for this.

these countries can specialize in goods where human capital is relevant as witnessed by the intrusion of newly industrialized countries into the realm of North-North intra-industry trade (see Wörz 2005). [24]

Worker remittances: Income difference and opportunity costs

We started from the idea of Chami et al. (2005) that remittances might depend on the difference of the GDP per capita of the receiving countries and that of the OECD countries.

$$WR/GDP = -0.12 - 2.95\,WR(-1)/GDP(-1) - 0.08\,LOG(1+RIUSA(-1)) - 12.3\,(WR(-1)/GDP(-1))^2$$
$$(0.005)\quad (0.012)\quad (0.0001)\quad (0.0079)$$

$$-226.15\,(WR(-1)/GDP(-1))^4 - 0.005(LOG(WR(-1)/GDP(-1))) - 7.17\,(LOG(WR(-1)/GDP(-1)))^{-3} \quad (2')$$
$$(0.0003)\quad (0.0079)\quad (0.0013)$$

$$0.034(LOG(OEC(-2))-LOG(GDPPC(-2))) - 0.003(LOG(OEC(-2))-LOG(GDPPC(-2)))^2$$
$$(0.06)\quad (0.06)$$

Per.: 34 (1972-2005); Countr.: 51; Obs.: 777. Adj. R^2 = 0.926; DW stat.: 2.02.

Worker remittances as a share of GDP depend on its own past values in a non-linear way as one might expect of variables at the beginning of their history.[25] The sum of all lagged dependent variable expressions has a negative value of about 0.06 if we plot it against the growth rate of the remittance ratio. A negative value is plausible if sending money in one year implies a reduction in the next, be it because of the negative correlation of unfavourable shocks or because of the limitations in money available. Next, interest rates in the USA reduce remittances, indicating that they are also competing with investment elsewhere, which is typical for investment oriented expenditures but could also hold for others. Domestic interest rates are insignificant. This confirms the result by Vargas-Silva and Huang (2006) for a smaller sample that home country variables have a weaker impact on remittances than host country variables. Public expenditure on education as a share of GDP is a variable that is highly insignificant once we use panel corrected standard errors of the cross-section-weight type. If we drop it net immigration flows also become insignificant.

[24] We have abstained from trying other human capital indicators because their endogenization would make the model even more complex and in poor countries the variation of literacy is as wide as that of secondary schooling. We want to point out though that in the literature all growth regressions for poor countries with significant human capital indicators do not employ the export growth part of our regressors although capital goods are imported.

[25] When the GDP part of a variable appears with a fraction sign for variables we have made ourselves, we have algebraic values like 0.02. Then high positive exponents make them even smaller because they are below unity as in the case of wr/GDP. The variables without a fraction sign like peegdp are taken from the WDI and 6% then is 6 because the World Bank multiplies them by 100.

Savings: The effects of worker remittances and aid

The results are as follows.

$$SAVGDP = 5.92 + 0.67\ SAVGDP(-1) + 79.1\ WR(-1)/GDP(-1) - 338(WR(-1)/GDP(-1))^2 - 0.006(PEEGDP)^2$$
(0.0001) (0.0000) (0.013) (0.004) (0.000)

$$-24.1\ ODA/GDP + 40.1(ODA(-1)/GDP(-1))^2 + 22NM/L \qquad (3')$$
(0.027) (0.072) (0.004)

Periods: 7 (1975-2005). Countries: 41. Observations: 106. Adj. R^2 = 0.86; DW stat.: 0.85.

The lagged dependent variable has a positive impact. Worker remittances have a positive slightly decreasing effect for the relevant range until 11.7% of GDP. Public expenditure on education (squared) has a slightly negative impact: if the government spends more on education households save less. Official development aid has a negative impact even if aid were tripled. Finally, an increase in net immigration, or less emigration, would increase savings ratios. Again we have a high loss of observations from gaps in the data. We also have a low Durbin-Watson statistic, but we don't worry about it here because it is probably due to the low number of observations in the time dimension when five-yearly migration data are used.[26]

Interest rates depend on past debt flows and aid

In an open economy context savings do not equal investment and their effect on growth may come through interest reduction for investment, if it has some effect, or through later use of savings as expenditure on education causing a negative effect on labour force growth. We consider first the effect of savings and other variables on interest rates.

$$LOG(1+RI) = -0.105 + 0.54LOG(1+RI(-1)) - 0.28LOG(1+RI(-2)) + 0.80(LOG(GDPPC))-LOG(GDPPC(-1)) \qquad (4')$$
(0.023) (0.00) (0.00) (0.0004)

$$+ 1.57\ ODA/GDP - 5.83(ODA/GDP)^2 + 0.92(ODA(-1)/GDP(-1))^2 + 0.0084[\text{Sum-of-Lags } (INVGDP(-2)-SAVGDP(-2))]$$
(0.004) (0.00) (0.047) (t-value: 2.165)

Periods: 25 (1981-2005). Countries: 34. Observations: 406. Adj. R^2 = 0.68; DW = 1.95

Real interest rates depend on their own two lagged values. Growth rates of GDP per capita enhance them. Official development aid also has a positive impact in the relevant range with a maximum of 16% - beyond which higher interest rates might increase the probability of

[26] Interest rates could be added to this equation at the cost of reducing the significance of other variables and changing their values. In simulations the result are too high savings, going beyond investments, which is never the case in the sample period. Using the Arellano-Bover method we get lower coefficients of the lagged dependent unless the number of instruments is two-thirds that of the observations; then we get about equal coefficients but no constant; therefore we stick to the fixed effect method.

bankruptcy - and a zero at 32%. Probably the reason is that aid signals a weak future ability to pay and therefore increases spreads. Tying of aid to co-financing investment may raise credit demand and interest rates. The difference between investment and savings increases foreign debt, and therefore also spreads, with a lag of two years. The result is based on a polynomial distributed lag of the eighth degree with 14 lags. We have used polynomial distributed lags because past flows of debt are collinear with each other. There are no direct effects of remittances on interest rates in this sample.

Investment increases with aid and indirect impacts of remittances

The preferred regression for investment is as follows:[27]

$$\underset{(0.00)}{LOG(GFCFGDP) = 0.52} + \underset{(0.00)}{0.776}LOG(GFCFGDP(-1)) + \underset{(0.00)}{0.45}D(LOG(GDPPC(-1))) + \underset{(0.002)}{0.27}(ODA(-1)/GDP(-1))$$

$$+ \underset{(0.05)}{31.25}\, D(LOG(L(-1)))^2 - \underset{(0.06)}{24.89}\, LOG(1+D(LOG(L(-1))))^2 + \underset{(0.006)}{0.028}LIT(-5) \underset{(0.01)}{-0.0265}\, LIT(-6) \qquad (5')$$

Periods: 30 (1974-2005). Countries: 43. Observations: 1066. Adj. $R^2 = 0.86$; DW = 1.96

Aid and lagged growth rates of GDP per capita have a positive impact on investment. Remittances having an impact on growth therefore have an indirect impact here. The effect of aid may also stem from tying aid to the export of donors countries machinery sector. Boone (1996) is often cited as finding a negative impact of aid on investment. However, he reports positive effects for small countries with high aid/GDP ratios, which are generally small and poor countries as many in our sample. Labour force growth and changes in literacy have both a positive impact on investment. We will see next that remittances enhance literacy and therefore they have a second positive indirect impact here.

Public expenditure on education: Tentative arguments behind the political decision

The second type of investment besides fixed capital formation is public expenditure on education. This is a highly political variable. Our most plausible result is as follows.

$$PEEGDP = 0.66 + 0.84\, PEEGDP(-1) - 0.0226\, PEEGDP(-1)^2 + 0.04\, TAXY + 1.69\, ODA(-5)/GDP(-5)$$

[27] Investments are independent of interest rates or, alternatively, would have a positive sign, which could be justified by a strong impact of credit rationing for a large part of investors. Under credit rationing investments are limited to savings, for example of producer households, and savings react positively to interest rates and so do investments. If the share of the population suffering from credit rationing is large enough, a positive impact of interest rates on investments is also plausible. We use the regression without positive interest effect because it has a much higher adjusted R-squared and it covers eight countries more. Moreover, in our counterfactual exercise the impact of aid on investment and interest rates is implausibly large.

(0.015) (0.00) (0.018) (0.023) (0.008)

+ 0.114 LOG(WR(-1)/GDP(-1)) (6')
(0.0012)

Periods: 25 (1981-2005). Countries: 35. Observations: 219. Adj. R^2 = 0.95; DW = 2.07.

Public expenditures on education are positively related to the amount of taxes raised (by the central government as a share of GDP). Remittances and aid have positive effects in poor countries. Governments react positively to aid and remittances, which could express an attitude of co-financing: if donors and domestic people put in more money the government may get convinced of doing the same, in particular because they do not have to pay alone.

Change of literacy is financed by aid, savings and peegdp

Public expenditures on education enhance literacy. We have to resort to polynomial distributed lags (Almon lag) again probably because it takes between zero and five years until money financing beginners or preventing drop outs has an effect.

LIT = 8.2 + 0.831LIT(-5) + 6.465ODA/GDP + 0.09512 [sum of lags savgdp] + 0.75[sum of lags peegdp] (7')
(0.02) (0.00) (0.063) (t-value:1.94) (t-value:2.13)

Periods: 18 (1985-2004). Countries: 30; Observations: 171. Adj. R^2 = 0.99; DW = 0.81.

Development aid, savings and public expenditure on education all enhance literacy. For savings there are three lags and the current value and for public expenditure on education there are four lags and the current value. Polynomial distributed lags are well know to cause serial correlation resulting in a low Durbin-Watson statistic here. As all these variables are measured as a percentage of the GDP it is interesting to see the differences in the coefficients. Development aid has the highest coefficient, perhaps because aid, for example from the Netherlands, is often tied to education. Probably this induces some reduction of private savings being used for this purpose because they have the lowest coefficient. But this reduction is still imperfect because under imperfect capital markets savings remain important. There is no complete crowding out of private money and we do not know what the coefficient would have been without aid. The effects of emigration and remittances on savings presented above have an indirect effect on literacy. Similarly, the effect of remittances on public expenditure on education has an indirect effect on literacy. The simulations yield values, which are close to those of the panel average at

the last year of the sample and therefore are very realistic for those years which are at the border between out-of-sample forecasting and within-sample forecasting.[28]

Another variable that is highly political in spirit is the ratio of central government tax revenues to GDP. Our result is as follows.

TAXY =

$$1.3 + 0.83\ TAXY(-1) + 0.0012\ TAXY(-1)^2 - 7.53\ WR/GDP + 51.1(WR(-1)/GDP(-1))^2 + 0.05\ SAVGDP \quad (8')$$
(0.05) (0.00) (0.018) (0.09) (0.0008) (0.0013)

Periods: 31. Countries: 35. Observations: 348. Adj. $R^2 = 0.975$; DW = 2.02.

Tax ratios depend on their own lagged values and a very small quadratic one, which is positive. Worker remittances have a negative impact in the relevant range. Via this channel remittances reduce education working against the positive effects discussed above. But if people save more, indicating a higher surplus product, the tax ratio is also increased.

Aid: Donors react to growth of the poor countries and their own

Of all the variables, which are important for literacy all but official development aid have been discussed so far.

$$ODA/GDP = 0.016 + 0.82\ ODA(-1)/GDP(-1) - 0.0186\ d(LOG(GDPPC(-1))) + 0.056\ D(LOG(OEC(-2))) \quad (9')$$
(0.00) (0.00) (0.0004) (0.0007)

Periods: 43 (1963-2005). Countries: 52. Obs.: 1775. Adj. $R^2 = 0.90$; DW = 2.18.

Aid as a share of GDP depends on its own lagged value and is negatively dependent on the growth rates of the recipient countries and positively on that of the OECD countries, the major donors. In other words, aid is reduced if a country is doing better relative to the donors. Low growth countries will therefore keep a high share of aid, but high growth countries will get less aid. This equation could probably be enhanced by including motives for paying aid in a more detailed way. However, the focus of this paper is the level - because we need it for the simulations - and not the detailed motives and therefore we keep the equation simple. Moreover, some motives may be grasped by the lagged dependent variable and time invariant motives are implicit in the fixed effects. As with some of the other regressions, many alternative specifications tend to deliver too high simulation values for aid in the years close to 2005.

Endogenous labour force growth

[28] Two properties for within-sample forecasting are presented in Table A.1: Theil indices and covariance proportions of the mean squared forecast error. Figures and Tables with names starting with 'A' can be found in an appendix of the working paper version.

Literacy has no direct impact on growth but an indirect one via the labour force growth equation. Migration also has an impact on the labour force growth. These are two indirect channels for remittances to have an impact on growth via labour force growth.

$$D(LOG(L)) = c_{10i} + \underset{(0.005)}{0.17}D(LOG(L(-1))) + \underset{(0.005)}{1.39}\,D(LOG(L(-1)))^2 - \underset{(0.025)}{0.00018}\,LIT(-13) + \underset{(0.09)}{0.015}\,ODA(-5)/GDP(-5) +$$

$$+\underset{(0.05)}{0.04}NM/L + \underset{(0.12)}{0.018}\,D(LOG(GDPPC(-1))). \qquad (10')$$

Per.: 4 (1990-2005). Countr.: 43. Obs.:153. SEE: 0.0072. J-stat.: 72.4. Instr.rank:71. p(J): 0.25

Labour force growth depends on its own linear quadratic lagged values. Literacy as of 13 years ago reduces it. This effect probably stems from lower population growth 13 years earlier. Development aid as of five years earlier also enhances labour force growth. This is probably due to financing primary schooling through aid or to emergency aid and poverty alleviation reducing starvation from hunger and diseases and thereby allowing people to stay in the labour force later. Net immigration also increases the labour force immediately, indicating that people are allowed to immigrate for the purpose of work. Finally, growth of GDP per capita in the previous year encourages people who did not believe in the chance of getting a job to enter the labour force.

Via net immigration more variables may have an impact on the labour force growth. Essentially, net emigration would reduce labour force growth and therefore can be expected to be growth rate enhancing in an indirect way. Therefore we turn to net immigration next.

$$NM/L = c_{11i} - \underset{(0.06)}{0.18}NM(-5)/L(-5) + \underset{(0.002)}{2.97}(LOG(GDPPC)-LOG(OEC)) + \underset{(0.0014)}{0.73}(LOG(GDPPC)-LOG(OEC))^2$$

$$+\underset{(0.0013)}{0.058}(LOG(GDPPC)-LOG(OEC))^3 + \underset{(0.0000)}{1.29}\,WR(-10)/GDP(-10) - \underset{(0.006)}{1.36}(WR/GDP)^2 +$$

$$+\underset{(0.0000)}{12.8}(WR(-5)/GDP(-5))^2 - \underset{(0.000)}{19}(WR(-10)/GDP(-10))^2 - \underset{(0.0001)}{0.00118}SAVGDP(-3) \qquad (11')$$

Per.: 4 (1990 2005). Countr.: 20. Obs.: 46.[29] S.E.E..: 0.012655. J-stat.: 23.69. Instr. Rank 30. p (J): 0.31

The lagged dependent variable normally is interpreted to reflect network effects (see for example Hatton and Williamson 1998, Chap.4, and Mayda 2007) and expected to have a positive sign. We get a positive sign for an OLS estimate, but a negative one when using fixed effects or the Panel systems GMM reported. The negative sign may stem from migration that is

[29] Remittance data are available for all 52 countries but only since 1971. GDP per capita data are available for all 52 countries and 46 periods, but with some gaps: instead of 52x46 = 2392 we have only 1957 observations. Savings data start in 1965 with gaps again, leaving us with 1423 observations instead of 41x52=2132. As a consequence we loose more than half the possible observations in both dimensions

caused by natural disasters or political conflict including war and civil war. These may be negatively correlated with similar events five years later. In addition, if a person in a network has financed the costs of migration for one person then, for relatively poor countries like those in our sample, the probability that another one can be financed five years later may be very low and affected negatively. This may be different for large stocks of migrants - of which we do not have the adequate data though – when such uncertainties and fluctuations are averaged out over a large number of people. Our result is more plausible for small stocks of migrants with much temporary migration as Hatton and Williamson (2002) report for Africans in the USA constituting a small network whose behaviour may resemble that of single persons in the presence of fluctuations.[30] The second argument is the backwardness in GDP per capita, *GDPpc*, relative to that of the OECD, *OEC,* which matters in a highly non-linear way. Most international migrants in the meanwhile go to OECD countries. However, many do not but go to richer neighboring countries. Only 15% of the migrants to the OECD come from low-income countries (Skeldon 2008). Countries that are loosing people to the OECD directly are willing to allow for immigrants from other countries. These countries in turn are willing to allow for immigrants from the next poorer countries. This constitutes a chain from rich to poor countries, where the incentive essentially stems from the rich end of the chain. In this perspective the GDP per capita in the OECD reflects the income that can be earned in the upper end of the chain. This income difference is only a rough indicator of what the migrant gets as an income change when changing the country of his location. Of course, he may not exactly have the average income before and after migration and the probabilities of getting a job in the new and old locations may differ but still the income difference between the places of origin and destination is a good proxy for the revenue gain of the national and international migrants since the work of Todaro (1969) (see Mayda 2007 for an extensive discussion of modern literature).[31] According to our combination of data and simulations presented below the gap increased from -3.4 to -3.7 in the period 1960-1990, and falls slightly afterwards; then catching up takes place in our simulations until a value of (-2.96) in 2155 when our simulation ends. Figure A.1c shows the plot of the arguments as in the regression for the relevant range of our simulations presented below. It has a u-shaped form along which the economy moves as indicated in the main text: first to the left, then to the right. Therefore this part of the incentives for migration increased until 1990 (see also Hatton and Williamson (2003)), then remained constant and thereafter is slightly reduced.

[30] Hatton and Williamson (1998, chap.4) report strong volatility for migration streams before WWI.

[31] Hatton and Williamson use wages instead of income in their papers. Note that for a CES production function wages are proportional to per capita GDP.

The next argument appearing in the form of current and lagged, linear and quadratic terms are worker remittances as a share of GDP.[32] This is what those who are left behind by the migrants get in order to solve the market imperfections like insurance problems and related credit constraints emphasized by modern migration theory (see Stark and Bloom 1985, Taylor 1999 and Rapoport and Docquier 2006). For the European migration to the US before WWI Hatton and Williamson (2003) emphasize that remittances financed further emigration. Figure A.1a shows that this effect increases net immigration and reduces emigration in a slightly non-linear way. As worker remittances as a share of GDP are between 2.5 and 3 per cent there direct effect is that they reduce net emigration by about 3 percentage points. This makes sense because reducing problems from market imperfections makes sense only if some members of the family want to stay in the country of origin. The effect emphasized by modern theory therefore seemingly dominates the one of financing additional migration. Unfortunately the remittance data are received payments. We do not have the data for remittances paid or only versions including non-migrant labour income from abroad. This may lead to an omitted variable bias, at least for countries with two-way migration. However, to the best of our knowledge, earlier regressions with migration as a dependent variable did not take into account remittances at all, although they are the return of the family decision for those who stay at home according to the new economics of labour migration. Even if we are missing remittances paid we provide an improvement to the state of the art here by taken a remittances variable into account in a migration equation.

The last regressor[33] is the savings ratio as of three years ago. In poor countries with less than $1200 per year or $100 per month it will hardly be possible to pay migration costs out of current income even if reconsidered in terms of purchasing power parity. It is necessary to save first. Whereas the income difference and remittances represent the incentives to migrate, the lagged savings ratio represents an important part of the means available to carry the costs. Remittances then finance emigration via their impact on savings. With a savings ratio of 1/6 = 16 2/3 % an average family saves $200 of the $1200 or $100 if it is half as rich. Over three years this cumulates to $300. This might be enough to cover the migration costs without being payable out of current income. Figure A.1b plots this part of the regression for the relevant data range of our simulations below. For low savings ratios as in the early 1960s the savings ratio

[32] Note that worker remittances as a share of GDP is a value below unity. Therefore the exponents do not have a strong impact as they would for values above unity.

[33] Other regressors, which are not used in the regressions, are discussed broadly in Appendix 4 of the working paper version.

explains about 1% of net emigration. For high savings ratios of later years this goes up to 2.5 percentage points.

Reading the order of magnitude on the vertical axis, the classical income difference argument explains most of net migration. However, in terms of economic causality emigration is not possible without the savings accumulated in order to cover the costs of migration. It is interesting to note that the vertical difference between the interior minimum and the maximum of the curve in Figure A.1c is about 8 percentage points, for worker remittances as a share of GDP there is a difference of 4 percentage points between the highest and the lowest value, and for the savings ratio it is 1.25 percentage points. Therefore none of these is negligible relative to the others. We will see below how all regressors interact to result in a path of net migration.

The eleven equations provided so far are the heart of the model. In addition, we have used US interest rates in equation (2') for remittances, world income in the growth equation (1') and OECD income in the migration equation (11') and the aid equation (9'). For these variables we provide only auxiliary equations as is the habit in dynamic stochastic general equilibrium models (see for example Acosta et al 2007). The result of the VAR and ECM procedure[34] are the equations presented below. For US interest rates we find that they depend only on their own lag.

$$RIUSA = 0.59 + 0.85RIUSA(-1) \qquad (12)$$

(12)

(0.0422) (0.00)

Periods: 43 (1963 -2005). Adj. R^2 = 0.718. DW: 1.785

The growth rate of the world GDP is seen as a function of time mimicking its own technical change, its own lag capturing cycles and perhaps the transition to a steady state, and the growth rate and its lag of the GDP per capita of the OECD, and the US interest rate.

$$LOG(WLD) = 3.31 + 0.0034T + 0.89LOG(WLD(-2)) + 1.12D(LOG(OEC)) - 0.0024RIUSA \qquad (13)$$

[34] The procedure consists of estimating a VAR, determining the optimal lag length, checking for stability, estimating a VECM with one lag less and verifying the endogeneity of the variables. In our case US interest rates and OECD per capita income are exogenous. Estimation of the autoregressive model for the log of the world GDP with US interest rates and OECD growth rates and a time trend after elimination of insignificant lags and autoregressive equations for US interest rates and OECD per capita GDP complete the model. The lagged dependent variables in these equations introduce a bias. But the estimator is consistent as the Breusch-Godfrey test shows that there is no serial correlation. Having by far more than 30 degrees of freedom the bias will be small enough to allow for least squares estimation (Ramanathan 2001). Standard errors for these equations are heteroscedasticity and serial correlation consistent (Newey West HAC).

(0.0005) (0.0015) (0.00) (0.00) (0.0001)

Periods: 43 (1962-2004). Adj. R^2 = 0.999; DW = 1.95.[35]

Finally, we regress the log of the GDP per capita of the OECD on a constant, a time trend and three lags:

$$LOG(OEC) = 1.063 + 1.2LOG(OEC(-1)) - 0.54\ LOG(OEC(-2)) + 0.23LOG(OEC(-3)) + 0.00214T \quad (14)$$

(0.014) (0.00) (0.004) (0.161) (0.051)

Periods: 43 (1962-2004). Adj. R^2 = 0.998; DW = 2.04.

All the fourteen estimated equations are used jointly to form a dynamic system. The signs of the significant effects for the whole system are summarized in Table 2 in order to allow for a quick check of dynamic interactions. The system is used for dynamic simulation and counterfactual analyses in the next sections.

5. Simulations with the dynamic system

Remittances have not only a direct effect on growth but also direct effects on savings, migration, public expenditure on education, and taxes revenues. Indirect effects go via savings to public expenditure on education and on literacy, and from there as well as from migration to population and labour force growth. The simulation of the system allows us to take all of these effects jointly into account. Thereby we automatically include second and higher round effects, which are missing in many other types of studies (see Adams 2006).[36]

The simulation for equation (12) leads to a US interest rate of almost 4%. Equation (14) results in a value of about 1.97% for the growth of the GDP per capita of the OECD. World GDP moves to almost 3.1% according to equation (13). The other equations form a fairly complex non-linear system for which we cannot make many simple statements. The less complex curves though are moved into an appendix of the worker paper version in order to limit the number of figures.

[35] The saved residuals of this equation have no unit root. As mentioned above OECD income and US interest rates are exogenous here and therefore should not be part of an error correction term. Using lags in the regression is a method which contains level and first difference estimation as special cases. Other lags are insignificant. In a dynamic (or static) forecast the Theil index is 0.006 (0.004) and the covariance proportion of the MSFE is 0.986 (0.997). Bias and variance proportion are both below one percent. See Table A.1 for the Theil indices and covariance proportion values of the other equations.

[36] As all regressions employ lags of some variables we have to construct initial values for each series. We do this by regressing the variable in question on a constant and a (quadratic) time trend for the first five years or more if necessary and use simpler regressions in some cases for the early periods.

In Figure 1 the lower curve is net immigration as a share of the labour force.[37] Values are first negative and therefore we have emigration. The highest emigration of about 2.8% is obtained in 1989-1990. An implication from the negative sign of the lagged dependent variable in the migration equation is that the increase in emigration in the first phase does not come from self-perpetuating forces. Rather three forces are at work here explaining the phase of increasing emigration, the crucial and controversial part of the emigration curve sometimes called migration hump. First, after a very early peak of remittances as a share of GDP in 1979 (the highest curve in Figure 2) this percentage rate is falling providing less means for financing the desire to stay at home and solve problems from market imperfections. After the 1979 peak lower remittances contribute to higher emigration. Second, there is only a mild convergence of incomes; the income gap (see the lowest curve in Figure A.2) remains fairly large thereby stimulating further emigration.[38] Third, according to Figure A.2, savings are increasing in the first phase beyond 20% and allow financing more emigration and fall later below 15%, whereas investment is fairly stable above 20% of GDP. The fall in savings and the decreasing income difference are the dominant force for migration. Whereas the income differential changes only slowly the fall in remittances goes finally as far as zero because of its own non-linearities and negative effects of lagged variables.

The labour force growth (the curve which is the lowest in Figure 2 after the initial years) follows the emigration curve with a similar but less drastic curvature: The growth of the labour force goes down when emigration increases, and when net immigration goes up labour force growth follows. The growth rate of the GDP per capita (the second curve from above in Figure 2) reacts with the opposite tendencies. There is a strong interaction in the system between migration, growth of the labour force and GDP per capita.

In regard to the savings ratios we see that they follow the path of remittances, which first shoot up and then go down again. Tax revenues, going slightly beyond 14 percent of GDP, and public expenditure on education as a share of GDP, going a bit higher than 4 percent, as well as literacy, going to about 80 percent (see Figure A.3), do not reflect much of the ups and downs of migration and remittances. They all are not decreasing as much as savings do, indicating that the effect of savings on them is weak although it is significant. Rather public expenditure on

[37] The values of the first four periods stem from a simple regression on a time trend. These are needed as initial values as difference equation (11') has five-year lags. As we have also ten-year lags of remittances, we add lagged dependent variables next for some periods. This variant of our regression is used until 1983. From 1984 onwards we use regression equation (11'). The points of changes from the simplified regressions to (1)-(14) have always been chosen in a way that minimizes frictions at the point of switching to the estimated equation.

[38] Another major difference with European migration of that time is that much emigration came from relatively rich countries, the UK and its followers. Massey (1988) gives a detailed summary of the reasons for the migration into the USA.

education as a share of GDP parallels the pattern of total investment from very low values to a high and almost constant level although a value of not more than 80 percent is somewhat disappointing. Getting a better performance in regard to literacy requires a structural break. Finally, development aid goes to a maximum of 9.8% of GDP and then back to 9.4% thus contributing to the stable values of investment and education variables together with the stable value of taxes as a share of GDP.

In these simulations there are sum aspects which are highly sensitive to changes in the regressions, whereas others are very robust. The robustness is present in the first part of the migration hump. Slight changes in the regression can switch the point where emigration is half its maximum value in the end of our simulations by some decennia. This is easy to understand, because now it takes 160 years to get from 2.9 percent net emigration to 1.4%. That is a long period for a small change. A slight shift of the line upward or downward then easily translates into some decennia in the horizontal direction. One aspect that can easily change is whether or not savings will exceed investment. For example allowing for a positive interest rate in the investment and savings functions will increase investment, therefore also net debt flows, which in turn will enhance the interest rate again. However, this mechanism leads to savings larger than investment at times for within sample simulations although this can never be found for a panel average value at any time. It also increases the effects of more aid to be discussed in the next section dramatically and therefore we stick to the choice of an investment function presented above.

6. Counterfactual simulations[39]

The effects of reducing remittances to one half

In order to see the impact of remittances explicitly, we rerun the simulation with a value of remittances that is half of what they are in the baseline run of the previous section. Then we divide the values of the baseline simulation by those obtained with half of the remittance values. A look at Figures 2 and 3 as well as Figures A.4 and A.5 reveals that there is a strong impact of remittances on savings. Only the effect on emigration is stronger. Savings are 20% larger with remittances as shown by the highest curve in Figure 3. This increases emigration by up to one percentage point, for example for 2050 the value with remittances is 2.5% of the labour which would be only 1.5% with half the remittances and the reduced savings value. A higher

[39] The effects of doubling aid are discussed in a companion paper because the literature to be discussed is quite different.

emigration reduces the labour force growth as captured by the lowest curve in Figure 3. This then increases the growth rate of the GDP per capita (see Figure A.4) and leads to a permanent increase in its level (shown in Figure 3) running up continuously to 13% even going beyond that of savings for the last years. Another important effect of savings is that on literacy, making the latter four percent higher with full remittances. This also reduces labour force growth according to the regressions. The effects of literacy and emigration on labour force growth outweigh those of higher GDP per capita growth. Investment is enhanced by 2% according to Figure A.4 because the effects of literacy and growth outweigh the negative impact of lower labour force growth on investment. The effects on literacy are made possible by an increase of public expenditure on education of up to 5% and by higher savings. Public expenditure on education responds to 8% higher taxes revenues as a share of GDP, which in turn are due to higher savings again.

The effects of setting future net migration to zero

In spite of the problems of aging some political parties in rich countries advocate stopping migration. What would the implications for developing countries be? We capture the idea by setting net migration equal to zero from 2010 onwards. The stock of migrants would remain unchanged because each country could send out emigrant to the extent that they take immigrants including re-migrants. Rerunning the simulations with this constraint and dividing again baseline values by those of the counterfactual leads to results partly summarized in Figure 4. The main effect of migration is to lower the labour force growth as shown in the line beginning at the lowest level of Figure 4. This increases the growth rate by up to 3.2 percent. The effect on the level of the GDP per capita goes to more than 7%. By implication this contribution of migration to catching up reduces remittances to an increasing extent, because remittances depend on the log differences of the level of the GDP per capita with that of the OECD.

7. Summary and conclusion

The innovations of this paper are as follows. First, we estimate more equations than just one for growth of the GDP per capita getting the following main results. Remittances has not only direct positive effects on the level and growth rates of the GDP per capita but also on the rate of savings and public expenditure on education. But they also decrease tax revenues and

emigration.[40] Emigration has the direct effect of reducing the rate of savings and the rate of growth of the labour force.

A second major difference between our study and earlier ones is that we analyse the interactions between the effects of several equations in a dynamic system running simulations of the whole system. Stability of the model is shown through forward iteration of the model.

Third, we construct two counterfactual scenarios setting remittances to half their baseline value and net migration equal to zero. The first counterfactual result shows that a large impact of remittances is that of increasing savings. This enhances emigration, thereby reducing labour force growth, which in turn enhances GDP per capita growth. The second effect of remittances is enhancing education variables directly and indirectly via savings. Literacy helps reducing labour force growth and enhances investment, which in turn enhances GDP per capita growth. Moreover, remittances have positive direct effects in the growth regression. Savings are increased more than investment leading to a lower debt/GDP ratio in the long run. In the second counterfactual setting net migration equal to zero we find that the major impact of emigration is to reduce labour force growth, which in turn enhances the growth of the GDP per capita. Due to this contribution to catching up, however imperfect, worker remittances are lower than with net emigration.

This paper has not suggested anything normative for policy. As a suggestion for future research we like to support the view that remittances should be taxed less on both sides, the sender countries (Ranis 2007) and the receiving countries, because remittances are good for development in the poorer countries and could be encouraged this way. Stopping migration is bad for these countries unless they have a strong skill bias of migration, a topic going beyond the scope of our paper.[41]

[40] Ziesemer (2006) also considered a system of equations with remittances affecting only savings.

[41] See Schiff (2004), IMF (2005) and Docquier (2006) for sophisticated and well balanced discussions on the issue in which discounting though seems to be an absentee so far.

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Appendix 1: List of Countries

Countries with GDP per capita below $1200 (2000):

Armenia, Azerbaijan, Bangladesh, Benin, Bolivia, Burkina Faso, Cambodia, Cameroon, Comoros, Congo Rep., Cote d'Ivoire, Djibouti, Ethiopia, Ghana, Guinea, Guyana, Haiti, Honduras, India, Indonesia, Kenya, Kyrgyz Republic, Lesotho, Madagascar, Malawi, Mali, Mauritania, Moldova, Mongolia, Mozambique, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Papua New Guinea, Philippines, Rwanda, Senegal, Sierra Leone, Sri Lanka,
Sudan, Syria, Tajikistan, Tanzania, Uganda, Ukraine, Vanuatu, Yemen, Zimbabwe.

Appendix 2: Instrumental variables

This appendix provides the list of instruments used in the regressions, starting with the number of the respective regressions. The first number after a variable gives the first lag used and the second the last lag. These are used as dynamic instruments (see Baltagi (2005, Chap.8). If only one lag is mentioned we have a simple standard instrument.

(1): NM(-10)/L(-10), NM(-15)/L(-15), ((LOG(GDPPC)-LOG(OEC)),-1,-1), ((LOG(GDPPC) -LOG(OEC))^2,-1,-1), ((LOG(GDPPC)-LOG(OEC))^3,-1,-1), ((WR/GDP)^2,-1,-3), WR(-10)/GDP(-10), (WR(-5)/GDP(-5))^2, (WR(-10)/GDP(-10))^2, SAVGDP(-3).

(2): (D(LOG(L)),-2,-7), (D(LOG(L))^2,-2,-7), ODA(-5)/GDP(-5), LIT(-13), NM(-5)/L(-5), D(LOG(GDPPC(-1), -1,-5))

(3): (LOG(GDPPC),-5,-5), (LOG(GFCFGDP),-1,-1), D(LOG(L)), WR(-1)/GDP(-1), (WR(-1)/GDP(-1))^2, ODA(-1)/GDP(-1), (ODA(-1)/GDP(-1))^2 LOG(WLD(-1)), LOG(L(-1)), LOG(GDPPC(-1))-LOG(GDPPC(-6)), LOG(GDPPC(-2))-LOG(GDPPC(-7)).

The last two instruments in equation (3) are identical to the regressors added for serial correlation correction. They are not reported in the text and not included in the simulations.
Gross fixed capital formation is essential for growth, whereas for net foreign debt in the interest equation investment as a share of GDP matters. The difference of the two is inventories. There relation then is needed to come from one to the other.

Invgdp = 1.562113 + 1.003GFCFGDP; Adj.R^2 = 0.875; DW = 0.9
(0.01) (0.0000)

Table 1 Data description of the poor country sample

Variable	Panel average[a]	Growth rate[b]
Remittances/GDP	0.029	0.065
GDP per capita $	470	0.006
Investment/GDP	0.21	0.0143
Savings/GDP	0.13	0.069
net immigration/labour force	-0.0094	-0.00084[c]
Literacy	45.6	0.0244
Publ. exp. Educ./GDP	4.13	0.024
Tax rev./GDP	17.3	0.031
Labour force growth rate	0.021	0.0088[d]
Oda/GDP	0.089	0.0017[c]
Real interest rate USA	0.04	-
Real interest rate	0.012	0.0018
GDP per capita OECD	18975.43	0.0245
GDP World	$1.98x10^{13}$	0.034

a Least-squares dummy variable regressions of the variable on a constant.
b Least-squares dummy variable regressions of the natural log of the variable on a constant and a time trend.
c In case of negative values we use log(1+x) rather than log(x) in (b).
d Insignificantly different from zero.

Table 2: Signs of significant regressors

dep. variable	nm/l	gdppc	d(log(l))	wr/gdp	savgdp	gfcfgdp	ri	taxy	peegdp	lit	odagdp	wld	oec	riusa
regressors (a)														
nm/l	-	0	+	0	+	0		0	0	0	0	0	0	0
gdppc	+	+	+	-	0	+	+	0	0	0	-	0	0	0
d(log(l))	0	-	+	0	0	+		0	0	0	0	0	0	0
wr/gdp	+	+	0	+	+	0		-	+	0	0	0	0	0
savgdp	-	0	0	0	+	0	-	+	0	+	0	0	0	0
gfcfgdp	0	+	0	0	0	+	+	0	0	0	0	0	0	0
ri	0	0	0	0	0	0	+	0	0	0	0	0	0	0
taxy	0	0	0	0	0	0	0	+	+	0	0	0	0	0
peegdp	0	0	0	0	0	0	0	0	+	+	0	0	0	0
lit	0	0	-	0	0	+	0	0	0	0	0	0	0	0
odagdp	0	-	+	0	-	+	+	0	+	+	+	0	0	0
wld	0	+	0	0	0	0	0	0	0	0	0	+	0	0
oec	-	0	0	+	0	0	0	0	0	0	+	+	+	0
riusa	0	0	0	-	0	0	0	0	0	0	0	-	0	+
adj.R-sq.,(J-st.)	(24)	(75)	(72)	0.93	0.87	0.86	0.7	1	0.95	1	0.9	1	1	0.72

Figure 1: The migration hump and the effect of remittances

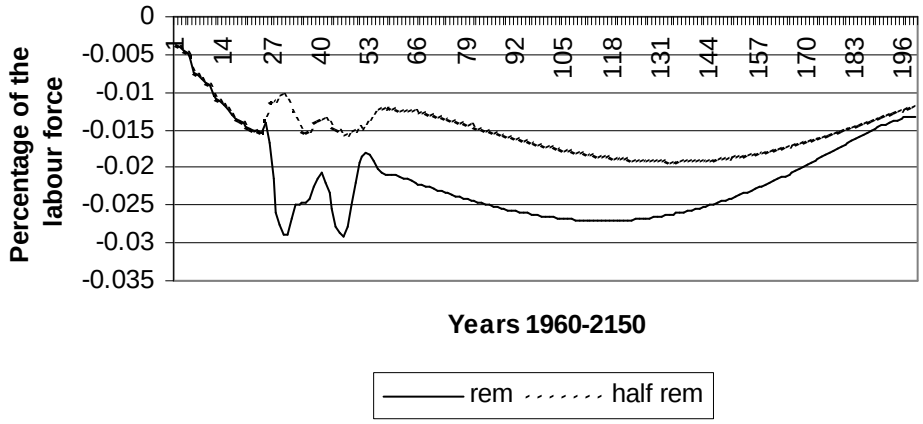
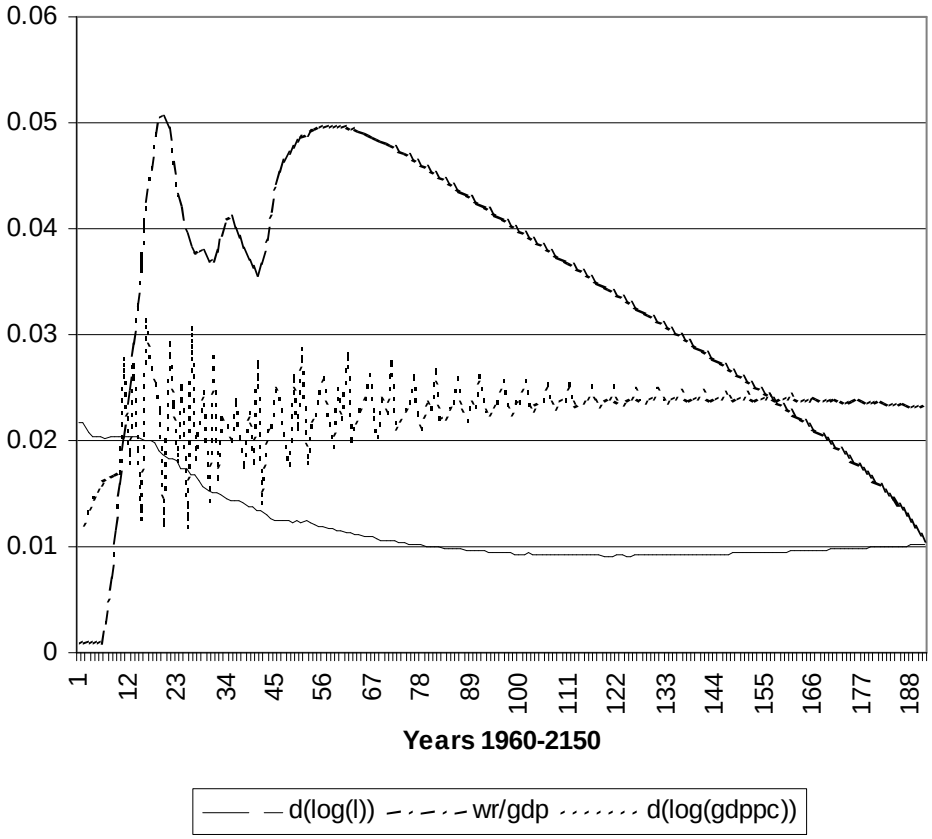


Figure 2: Labour force growth, GDP per capita growth and remittances as a share of GDP in poor developing countries



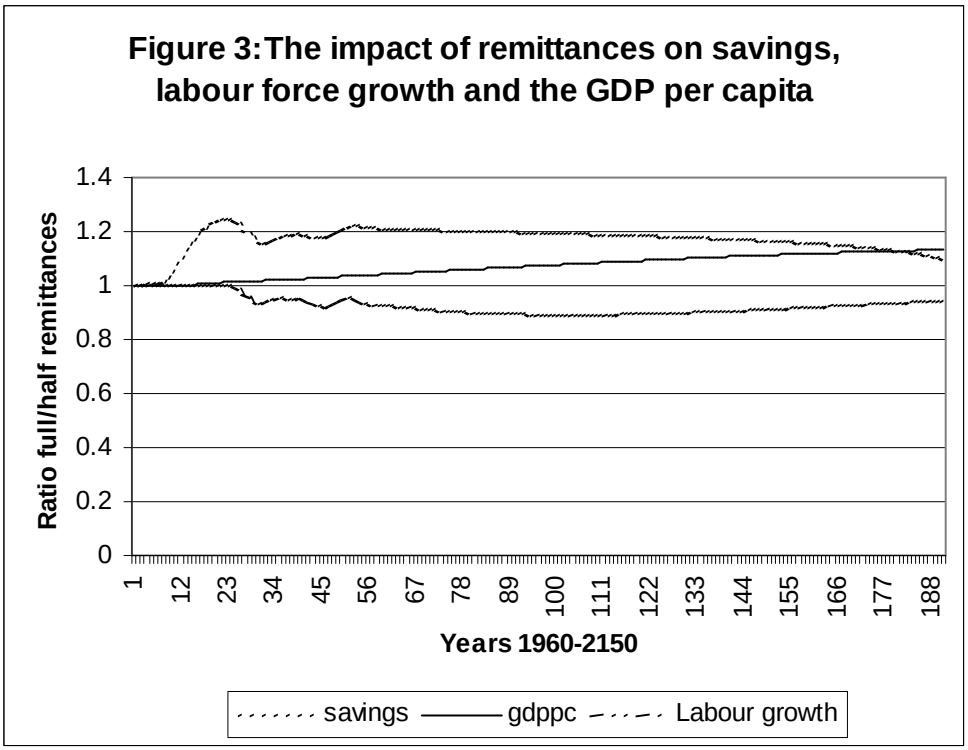


Figure 3: The impact of remittances on savings, labour force growth and the GDP per capita
Ratio full/half remittances
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
12
23
34
45
56
67
78
89
100
111
122
133
144
155
166
177
188
Years 1960-2150
savings
gdppc
Labour growth

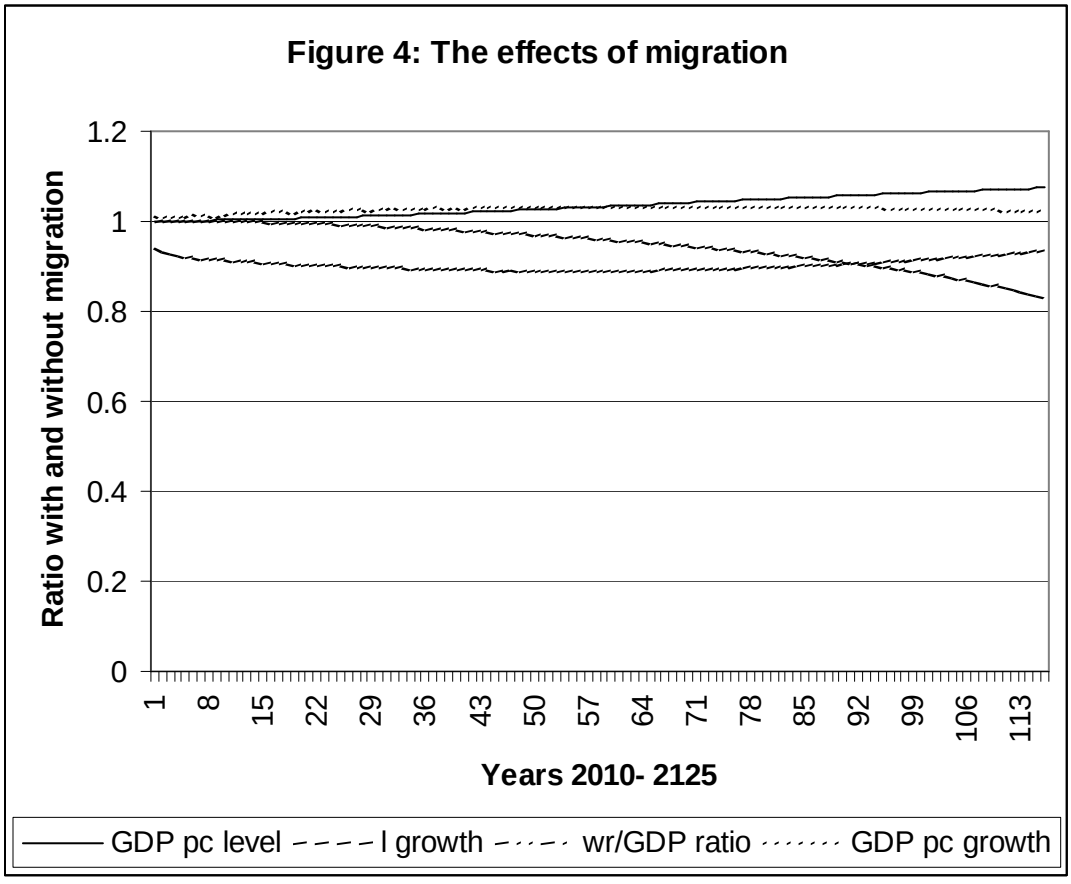


Figure 4: The effects of migration
Ratio with and without migration
1.2
1
0.8
0.6
0.4
0.2
0
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
113
Years 2010- 2125
GDP pc level
l growth
wr/GDP ratio
GDP pc growth

Appendix 3: Figures A.1a-A.5 (not for publication; for referees and working paper version only)

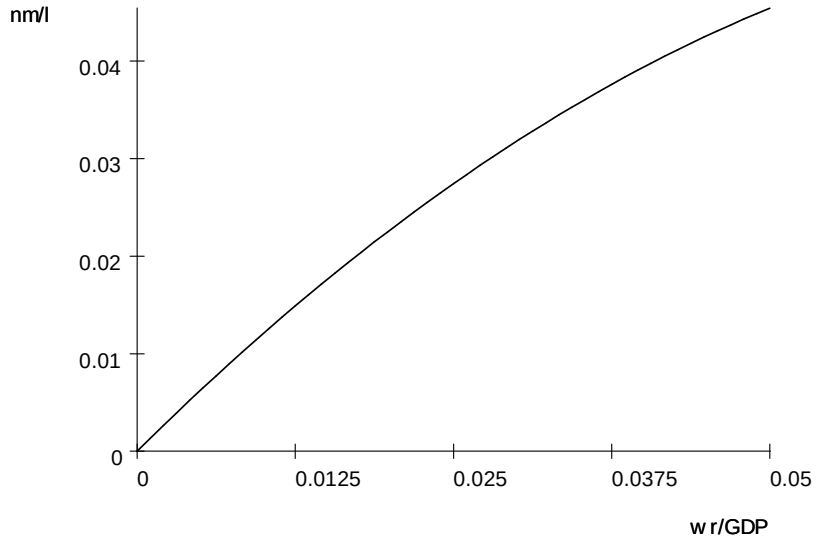


Figure A.1a Worker remittances as a share of GDP enhance net immigration as a share of the labour force.

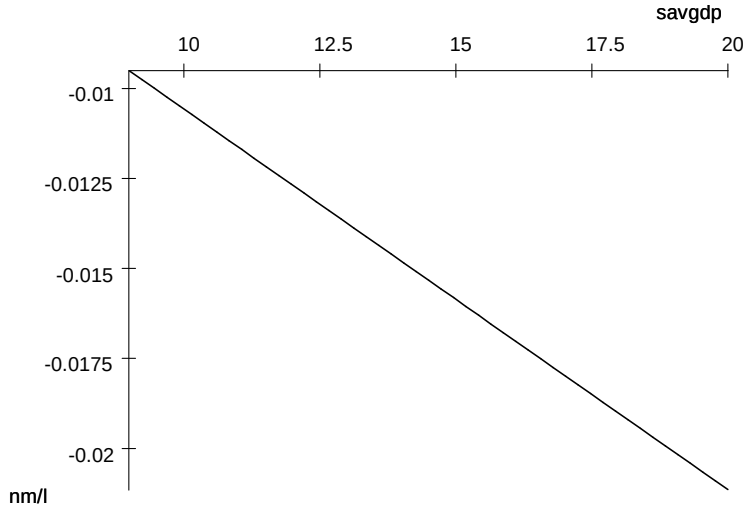


Figure A.1b The savings ratio reduces net immigration by about 1 percentage point at low values and by 2 percentage points at high values.

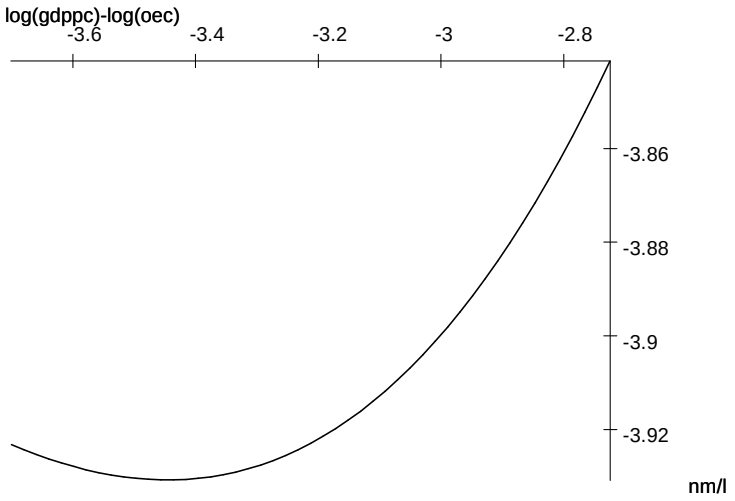


Figure A.1c The partial effect of long-run convergence (moving from left to right; after a temporary divergence from -3.4 to -3.67) between the per capita income of poor countries and that of the OECD decreases emigration. The data until 2006 are in the negatively sloped range of -3.38 and -3.67.

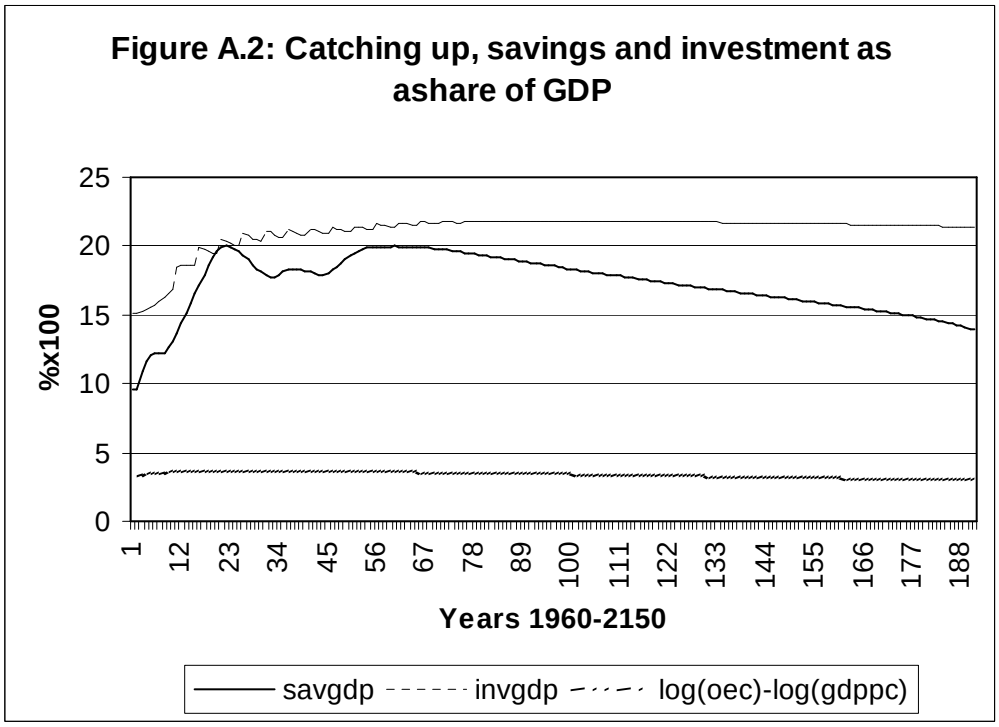


Figure A.3: Tax revenue and public expenditure on education as a share of GDP, and literacy

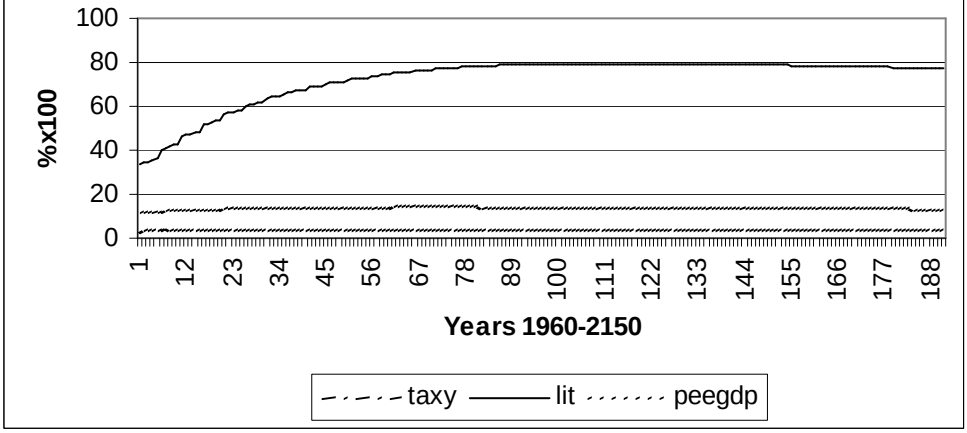
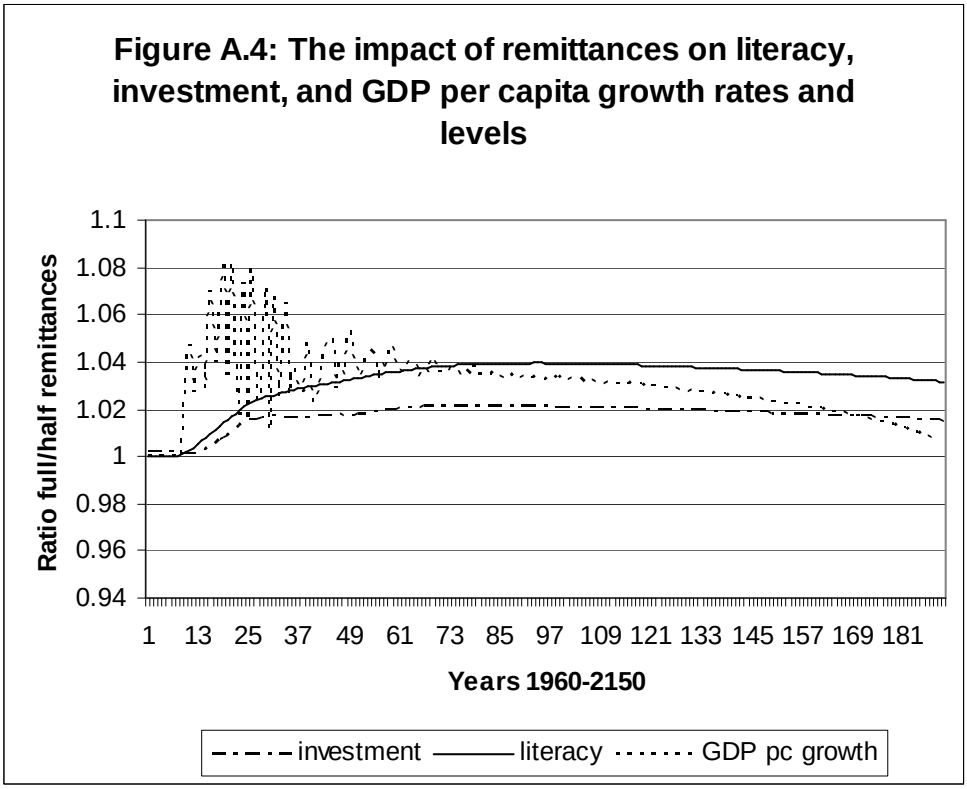


Figure A.4: The impact of remittances on literacy, investment, and GDP per capita growth rates and levels



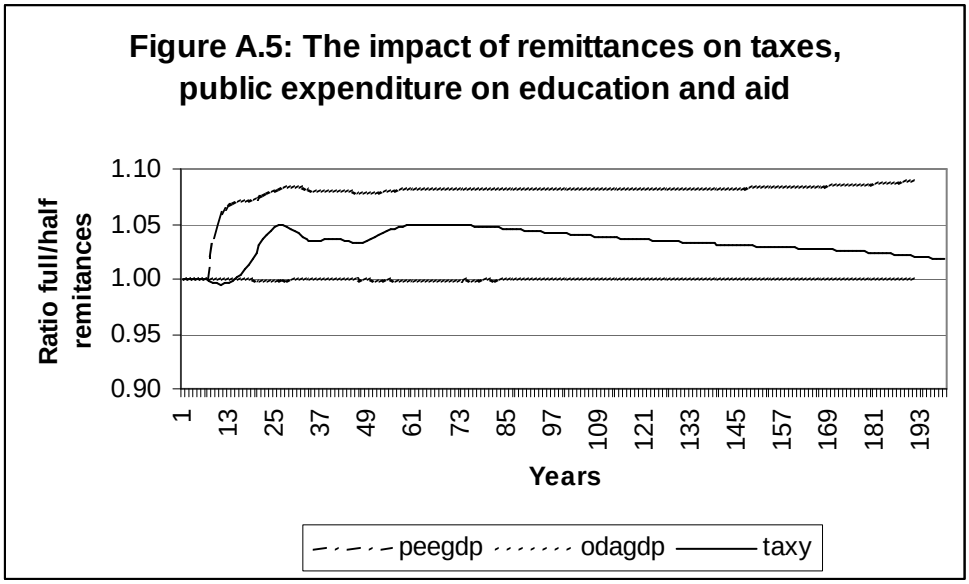


Table A.1
Forecast quality indicators for fixed effect versions of the regressions

Equation No.	*dependent variable*	*Theil index*	*Covariance proportion*
1	nm	0.126	0.98
2	d(log(L))	0.1	0.89
3	log(gdppc)	0.0068	0.999
4	wr/GDP	0.084	0.93
5	savgdp	0.074	0.977
6	log(1+ri)	0.28	0.917
7	log(gfcfgdp)	0.044	0.82
8	lit	0.007	0.97
9	peegdp	0.076	0.897
10	taxy	0.068	0.99
11	oda/gdp	0.17	0.96
12	riusa	0.138	0.92
13	log(wld)	0.00002	0.974
14	log(oec)	0.00087	0.937

Appendix 4: Other regressors for the migration equation? (Not for publication; for referee use and working paper version only)

We have also tried out several other regressors. Population growth rates were significant in the regressions of Hatton and Williamson (1998) for 11 European countries using data for 1860-1913, but are held to be not relevant in the literature on currently developing countries (O'Neill (2003)). However, rather than using lagged population growth rates as a reason for emigration pressure one can look at current labour force growth rates. In the fixed effects version the labour force regressor is highly insignificant as in the regressions of Vogler and Rotte (2000) although it is significant in the Arellano-Bover version of the GMM systems estimator. It seems to be an open issue whether or not population and labour growth contributes to emigration. For our simulations below results with and without this regressor are very similar. Similarly, a literacy variable is significant as long as we do not introduce the remittances variable. Its squared value can be made significant if we use two lags as instruments and thereby loose observations for 8 countries, but using only one lag as instrument we get an insignificant result. When the labour force growth is included as well the significance changes depending on which one is used with a lag. Pedersen et al. (2006) find that the literacy variable is insignificant for migrants going from Africa and Latin America to the OECD countries in a regression for bilateral data with random and fixed effects but without lagged dependent variables and remittances as regressors. In our sample 27 countries are from Africa and two from Latin America. Moreover, we have also tried adding a quadratic function of GDP per capita in order to capture more of the spirit of the migration hump. These are significant and result in a positive impact of GDPpc on immigration as in the bivariate regression of Lucas (2005) and in the fixed effects regression for Africa in Clark et al. (2007). However, when literacy is introduced the variable gets insignificant.[42] Because of this lack of robustness we drop them all, literacy, labour force growth, and the log of GDP per capita outside the income difference term.[43] The latter aspect of a hump shape in GDP per capita that would indicate the affordability of migration is nevertheless an outcome of the simulation presented below. For our purposes it is not important what the decomposition of the migrant population in regard to its characteristics is. Therefore we do not take into account aspects such as age of the population of origin, skills, land ownership and gender which are typically discussed in selection models and are not made for intertemporal simulations. They respond to different questions than ours. One can conclude from the model by Faini and Venturini (1994) that it is not necessary to include the costs of stemming immigration in destination countries, because this variable drops out in the derivation of the regression equation.

References of this appendix

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Faini, R. and A. Venturini (1994) Migration and Growth: The Experience of Southern Europe. CEPR

[42] In terms of the home bias model by Faini and Venturini (1994) this would mean that the utility function is of the Cobb-Douglas type in wages and home amenities and that in the Pareto function on necessary characteristics for migration, for example education, the scale parameter x_1 does not depend on wages in our sample. In their sample consisting of southern European countries the utility function is CES but not CD and the dependence on wages is significant.

[43] When including quadratic forms of GDP per capita there are two aspects that deserve some attention. First, for the migration hump to be an adequate interpretation one should find a maximum value that is not implausibly high. Second, for a dynamic interpretation one should make sure that over time migration should not grow explosively or have a share in the population or labour force that exceeds unity. These points have not been obeyed in all papers discussed above. Adding time trends does compensate for this only imperfectly in regard to forward simulations according to our experience.

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Pedersen, P., M. Pytlikova and N. Smith (2006) Migration into OECD countries 1990-2000. In: C.A. Parsons and T.M. Smeeding, *Immigration and the Transformation of Europe.* Cambridge University Press, 43-84.
Vogler, M. and R. Rotte (2000). The effects of development on migration: Theoretical issues and new empirical evidence. *Journal of Population Economics* 13, 485-508.World Bank (2007). *World Development Indicators*. Washington D.C.

Appendix: List of abbreviations (not for publication; for referee use and working paper version only)

c_i	constant of equation i
CD	Cobb-Douglas
CES	Constant elasticity of substitution
D, d	first difference operator
DSGE	Dynamic Stochastic General Equilibrium Model
DW	Durbin-Watson statistic
ECM	Error Correction Model
EGLS	Estimated Generalized Least Squares
er	emigration rate
GDP	Gross Domestic Prod
gdppc	Gross Domestic Product per capita
gfcfgdp	gross fixed capital formation as a share of GDP times 100
GLS	Generalized least squares
GMM	Generalized Method of Moments
GNI	Gross National Income
HAC	heteroscedasticity and autocorrelation consistent
invgdp	Gross investment as a share of GDP times 100
J-statistic	Hansen-Sargan function minimized by GMM
l	labour force measured as number of workers
LDC	less developed country
lit	percentage of the population above 15 which can read and write
log	natural logarithm
MSFE	mean squared forecast error
nm/l	net immigration per worker
oda/GDP	official development aid as a share of GDP
oec	GDP per capita of the OECD countries
OLS	ordinary least squares
PCSE	Panel Corrected Standard Errors
pdl	polynomial distributed lag
peegdp	public expenditure on education as a share of GDP times 100
ri	real interest rate
riusa	real interest rate in the USA times 100.
savgdp	savings as a share of GDP times 100.
S.E.E.	standard error of estimation
SUR	Seemingly unrelated regression
T	time trend, @trend
t	t according to student distribution
taxy	tax revenue as a share of GDP times 100.
VAR	Vector Autoregressive Regression
WDI	World Development Indicators
wld	GDP of the world
wr	worker remittances
wr/GDP	worker remittances as a share of GDP

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