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# Premises of Aid for Trade

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# 1. Introduction

The objective of the Aid for Trade Agenda is to enable developing countries to benefit from trade liberalization. Aid for Trade (AfT) seeks to build bridges between the development and trade communities as well as between the public and private sector. It involves external or foreign assistance to developing countries in the negotiation, design, implementation and assessment of policies aimed at

- helping economic actors – firms and households – in developing countries to benefit from and cope with structural change in international trade; and at
- “mainstreaming” international trade into domestic economic development.<sup>1</sup>

The underlying principle is that trade has the potential to substantially increase economic welfare. Exploring comparative advantages of particular goods, using economies of scale in production or taking advantage of technology spillovers, all these actions are likely to boost economic growth rates. Based on various theoretical models, abundant empirical literature has examined the welfare effects of trade (volumes) on income levels and growth rates. If anything, the majority of studies show that trade is positively associated with growth rates.<sup>2</sup> This view of trade fostering economic development, however, is not undisputed.<sup>3</sup> It has been shown that trade does not automatically lead to economic development, but rather only if certain preconditions are fulfilled, e.g., with respect to business regulations (Freund and Bolaky 2008) or institutional quality (Borrmann et al. 2006).

Our analysis contributes to this debate by exploring the prerequisites for a positive trade-growth nexus. More specifically, in an empirical analysis the relevant parts of the Aid for Trade agenda will be examined with respect to their potential to boost economic growth rates through trade. More specifically, we identify variables in three different areas that are crucial for the AfT agenda: institutions, infrastructure and human capital. As resources are not unlimited, it is especially important to find out which of the different areas reveal an empirical

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<sup>1</sup> According to the WTO, “mainstreaming” of trade “involves the process and methods of identifying and integrating trade priority areas of action into the overall framework of country development plans and poverty reduction strategies” (WTO document WWT/LDC/SWG/IF/1 of 29 June 2001, p. 1). As pointed out by Goldin and Reinert (2007, p.78, footnote 38), Aid for Trade and trade-related capacity building are “development ideas that are effected through foreign aid.”

<sup>2</sup> See Yanikkaya (2003) for a review of the extensive literature. Prominent studies are, for example, Dollar (1992), Sachs and Warner (1995), Frankel and Romer (1999), Dollar and Kraay (2002), Irwin and Terviö (2002), and Noguer and Siscart (2005).

<sup>3</sup> A critical view can be found in Rodriguez and Rodrik (2000).

influence of trade on economic growth. Most, if not all, of these variables clearly have a direct effect on economic development. Better institutions, better infrastructure and more human capital lead to higher economic growth. But the objective of AfT is to improve conditions in those areas which, apart from these direct effects, lead indirectly to higher economic development through the channel of trade. For example, an improvement in physical infrastructure facilitates trade, and the resulting increase in trade leads in turn to higher economic development. The crucial question in the discussion on AfT is in which areas such indirect effects can be found. To answer this research question, we constructed a comprehensive econometric model designed to explain growth differentials between countries. The empirical analysis uses a large data set, covering about 100 countries from 1971 to 2005.

It is intuitively obvious that a better educated population, a better infrastructure or higher quality institutions may result in higher GDP per capita growth. But one cannot rule out reverse causality, that is, that as countries get richer, e.g., as measured by GDP per capita growth, they invest more in education and infrastructure and experience an improvement in the quality of institutions. In econometric terms, such a situation is called an endogeneity problem, which is, to say the least, unfavourable for econometric analyses. Normally, in econometric modelling one would look for a situation with one variable of interest and then explain differences in that variable across countries and time using a set of explanatory variables that are independent of the variable of interest. But in our case, most of the control variables are very likely to be endogenous, including trade and unfortunately also the areas of top priority for the AfT Agenda, such as education, infrastructure, and institutions. Obviously, the indirect effects through trade of the AfT agenda are then also endogenous. As shown in Figure 1 by arrows going in both directions, the three types of variables not only influence the dependent variable, but are also influenced by the development of per capita growth over time. As a result, it is difficult to disentangle cause and effect for these crucial variables. Because standard econometric techniques would lead to biased results and cast doubts on reliability, a more sophisticated estimation approach is called for.

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graph TD; CV([Control Variables]) --> GDP([GDP pc Growth]); GDP --> CV; CV <--> AV([AfT Variables]); GDP <--> T([Trade]); AV --> T;
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Accordingly, we will first introduce the country sample covered, the variables used, and the econometric method employed in our analysis. Subsequently, we show the results and provide a discussion of the results, including various policy conclusions.

## 2.1 Variables and Country Sample

<sup>4</sup> Appendix C lists all countries included.

business cycles we use a total of seven five-year averages for all variables, from 1971-1975, 1976-1980 and so on, until 2005. In our model, we include the following independent variables:<sup>5</sup>

- *InitialGDPpc* describes the level of GDP per capita in constant 2000 US dollars for the last year of the previous period, i.e. GDP per capita in 1970 as the initial value for the period of 1971-1975.
- *PopulationGrowth* refers to the population growth rate in a country, including migration.
- *Investment* is the investment share of GDP.
- *Trade* equals exports plus imports of goods and services as a share of GDP.
- *Total (Secondary/Primary) Education* refers to educational attainment levels, quantified by the average years of total (secondary/primary) schooling of the population 15 years and older and serves as a proxy for human capital. The variable *Tertiary Education* refers to the average years of tertiary schooling of the population 25 years and older.<sup>6</sup>
- *Telecommunications* stands for the number of main telephone lines divided by total population as one important aspect of infrastructure.
- *Roads* refers to the total network of paved roads (in kilometres) divided by total population.
- *Railways* measures the total length of railway network (in kilometres) divided by the total population.
- *Power Generating Capacity* refers to the amount of kilowatt produced per capita.

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<sup>5</sup> A detailed description of the variables and data sources is given in Appendix A.

<sup>6</sup> Here we use the total population over 25 since youths between 15 and 25 have not yet completed tertiary education.

As a variable for the quality of political institutions, we include *Political Constraints*, which measures the extent of institutionalized constraints on the decision making powers of chief executives (Centre for Systemic Peace 2008). It is measured on an ordinal scale from 0 (periods of interruption, transition or interregnum) to 7 (executive parity or full set of checks and balances). In contrast to almost all other measures for institutional quality, this variable is available for many countries during a long period of time. However, as Table 1 shows, the partial correlations between *Political Constraints* and more accurate governance indicators, such as the World Bank Good Governance indicators (which are unfortunately only available from 1996 onwards) are reasonably high, rendering *Political Constraints* a good proxy for the quality of political institutions.

**Table 1: Partial Correlations Between *Political Constraints* and World Bank Good Governance Indicators, Average 2001-2005**

World Bank Good Governance Indicator	Partial Correlation with <i>Political Constraints</i>
Government Effectiveness	0.60
Regulatory Quality	0.68
Rule of Law	0.57
Control of Corruption	0.51
Political Stability	0.54
Voice and Accountability	0.86

Sources: World Bank (2008a) and Centre for Systemic Peace (2008).

Table 2 presents the means for the variables introduced above for all the countries included in our sample, as well as different subsamples. As expected, developed countries have higher levels of educational attainment, better infrastructure and lower population growth. The investment rate is higher and they benefit from better institutions. Developed countries have experienced higher GDP per capita growth rates, partly due to the inclusion of three “Tiger States” (Republic of Korea, Taiwan and Singapore) that experienced exceptionally high levels of GDP per capita growth in the 1970s and 1980s, but were relatively poor in 1970. In recent years, their growth rates have slowed down.

**Table 2: Means for Main Variables and Different Country Groupings, 1971-2005**

Variable	All Countries	Developed Countries <sup>1</sup>	Developing Countries <sup>1</sup>	
			Non-LDC	LDCs <sup>2</sup>
No. of Countries	98	29	50	19
GDPpcgrowth	1.81	2.50	1.94	0.40
ln InitialGDPpc	7.62	9.58	7.27	5.54
Population Growth	1.81	0.82	2.03	2.75
ln Investment	2.68	3.18	2.63	2.04
Total Education	5.47	8.32	5.12	2.06
Primary Education	3.68	4.99	3.70	1.65
Secondary Education	1.57	2.90	1.26	0.38
Tertiary Education	0.26	0.49	0.21	0.03
Trade	0.70	0.81	0.70	0.54
ln Telecommunications	-3.27	-1.12	-3.50	-5.91
ln Roads	-6.71	-5.01	-6.97	-8.26
ln Railways	-8.62	-7.68	-8.88	-9.33
ln Power Generating Capacity	-8.40	-6.50	-8.51	-11.00
Political Constraints	4.51	6.11	4.31	2.65

Notes: <sup>1</sup>World Bank classification, based on income per capita.

<sup>2</sup> Least developed countries according to UN classification.

## 2.2 Methodology

For the dynamic panel analysis, we start with a relatively simple specification that can be derived from an augmented Solow type growth model:<sup>7</sup>

$$(1) \quad GDPpcgrowth_{it} = \alpha_i + \beta_1 GDPpcgrowth_{it-1} + \beta_2 InitialGDPpc_{it} + \beta_3 PopulationGrowth_{it} + \beta_4 Investment_{it} + \beta_5 TotalEducation_{it} + \beta_6 Trade_{it} + \lambda_t + \varepsilon_{it}$$

where  $GDPpcgrowth_{it}$  stands for the GDP per capita growth of country  $i$  in period  $t$ ,  $\alpha_i$  is the country fixed effect,  $GDPpcgrowth_{it-1}$  represents the lagged dependent variable in the previous period,  $Trade_{it}$  is the variable of interest,  $PopulationGrowth_{it}$ ,  $Investment_{it}$  and  $TotalEducation_{it}$ , as introduced above, are further control variables,  $\lambda_t$  is a set of time

<sup>7</sup> We basically follow Mankiw, Romer and Weil (1992), who show that an augmented Solow growth model that includes accumulation of human and physical capital provides an excellent description of the data.

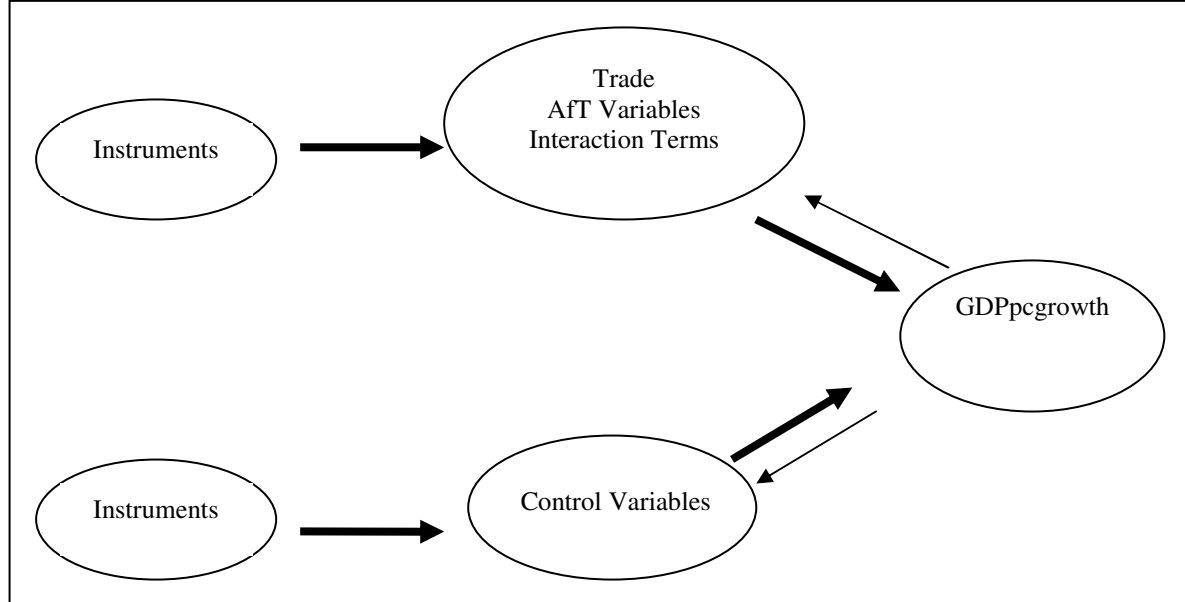


dummies, which is supposed to capture period specific effects, and  $\varepsilon_{it}$  stands for the error term. In subsequent regressions, we add further explanatory variables.

We expect a positive influence of the lagged *GDPpcgrowth* variable and a negative influence of the initial GDP per capita variable on current growth. For the different education variables, the infrastructure variables, the quality of political institutions and the trade variables, we expect positive coefficients.

Estimating equation (1) by ordinary least squares for the typical pooled cross-country time series analysis with “small T and large N” is very likely to produce biased coefficients due to the well-known problems that occur if some independent variables are endogenous (which is true for our sample). To solve this problem, we have to follow an instrumental variable approach, that is, to find instruments that are correlated with the endogenous explanatory variable but are not correlated with our dependent variable GDP per capita growth (see Figure 2).

**Figure 2: Estimation Strategy**



As our estimation strategy, we draw on the system-GMM estimator, which does not require any external instruments other than the variables already included in our dataset. In fact, it uses lagged levels and differences between two periods as instruments for current values of the endogenous variable. Significantly, the estimator does not use lagged levels or differences themselves for the estimation, but rather employs them to analyse the variation in the

endogenous explanatory variables in a given period and explain variation in the GDP per capita growth variable. This approach ensures that all information will be used efficiently and that we can concentrate on the impact of the explanatory variables on GDP per capita growth and not vice versa.

The procedure, suggested by Arellano and Bond (1991), eliminates as a first step the country-specific effects in equation (1) using first differences:

$$(2) \quad \Delta GDPpcgrowth_{it} = \beta_1 \Delta GDPpcgrowth_{it-1} + \beta_2 \Delta InitialGDPpc_{it} + \beta_3 \Delta PopulationGrowth_{it} + \beta_4 \Delta Investment_{it} + \beta_5 \Delta TotalEducation_{it} + \beta_6 \Delta Trade_{it} + \Delta \lambda_t + \Delta \varepsilon_{it}$$

where  $\Delta GDPpcgrowth_{it} = GDPpcgrowth_{it} - GDPpcgrowth_{it-1}$ . As a second step, we estimate equation (2) by using the differenced endogenous and predetermined explanatory variables with their levels in previous periods. Following this approach, we would get the Arellano and Bond difference-GMM estimator. This estimator, which can be thought of as an extension of the Anderson and Hsiao (1982) estimator, produces efficient (and consistent) estimates, since the latter estimator fails to take all the potential orthogonality conditions into account.

In two later papers, however, Arellano and Bover (1995) and Blundell and Bond (1998) reveal a potential weakness of the difference-GMM estimator. They show that lagged levels can be poor instruments for first-differenced variables, in particular if the variables are persistent. In their modification of the estimator, they suggest including lagged levels as instruments for the difference equation along lagged differences as instruments in the level equation. In contrast to the original difference-GMM, they term this expanded estimator system-GMM. In fact, the system-GMM approach estimates equations (1) and (2) simultaneously, by using lagged levels in equation (2) and lagged differences in equation (1) as instruments.

As we use lagged levels and lagged differences, the number of instruments can be quite large in a system-GMM estimator. Yet too many instruments can overfit endogenous variables and fail to expunge their endogenous components. Moreover, it also weakens the power of the Hansen test to detect overidentification. Since the risk can be quite high with this estimator, it has become common practice in the literature to keep the number of instruments below the number of observations, that is, the number of countries included in our sample. To avoid this

bias, we reduce the size of the instrument matrix in a number of regressions by restricting the number of lags used.

Significantly, in our estimation approach we capture the indirect effects of the AfT variables through trade on GDP per capita growth by including an interaction term between the AfT and the trade variable.

### 3. Empirical Results

#### 3.1 Main Results

Following the introduction of the variables and the econometric method used, we now turn to the main empirical results presented in Tables 3 and 4. To start, we show the results for the benchmark regression, that is, the augmented Solow growth model (column 1 in Table 3). Differences in GDP per capita growth across countries and time are explained only by GDP per capita growth of the previous period ( $GDPpcgrowth_{t-1}$ ), the initial level of GDP per capita (*Initial GDPpc*), *Population Growth*, *Investment*, educational attainment (*Total Education*) and *Trade*.<sup>8</sup> The coefficients of all variables have the expected sign. GDP per capita growth of the previous period has a positive influence on current GDP per capita growth, while the initial level of GDP per capita and population growth have negative influences. Investment, educational attainment and trade have the expected positive sign of the coefficient. The first four variables are significant at the 1 % level, with trade being significant at the 5 % level and educational attainment just missing the 10 % level. The condition that the number of instruments should be below the number of countries included in the regression is fulfilled (with 68 instruments and 98 countries in the first regression). The value of the Arellano-Bond-test AB(2) implies that problems of second order autocorrelation in differences can be ignored, while the values of the Hansen test show that the instruments are valid.

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<sup>8</sup> Variables, such as *Initial GDPpc* or *Investment*, are used in logs to reduce the skewness of the data.

**Table 3: Determinants of GDP Per-capita Growth**

Independent Variables	Dependant Variable: GDPpcgrowth					
	1	2	3	4	5	6
GDPpcgrowth (t-1)	0.149*** (2.697)	0.155*** (3.011)	0.156*** (2.868)	0.166*** (3.032)	0.156*** (2.835)	0.170*** (3.189)
ln InitialGDPpc	-1.161*** (-3.828)	-1.637*** (-4.034)	-1.543*** (-4.001)	-1.493*** (-4.265)	-1.988*** (-4.851)	-1.506*** (-4.877)
Population Growth	-0.514*** (-12.62)	-0.494*** (-14.05)	-0.479*** (-10.92)	-0.481*** (-10.02)	-0.450*** (-8.729)	-0.470*** (-9.846)
ln Investment	1.951*** (2.803)	2.226*** (2.304)	1.919*** (3.267)	1.507*** (3.205)	1.933*** (3.046)	2.057*** (3.499-)
Total Education	0.353 (1.62)	0.108 (0.567)	-0.428 (1.502)			
Trade	1.246** (1.997)	1.064* (1.874)	-3.070* (-1.925)	-3.305** (-2.023)	-1.546 (-1.211)	-0.86 (-0.910)
ln Telecommunications		0.701* (1.902)	0.974*** (3.211)	0.942*** (2.851)	1.174*** (4.242)	0.845*** (3.014)
Total Education * Trade			0.572** (2.367)			
Primary Education				-0.709* (-1.819)		
Primary Education * Trade				0.899** (2.42)		
Secondary Education					-0.338 (-0.566)	
Secondary Education * Trade					1.079* (1.868)	
Tertiary Education						-1.992 (-1.168)
Tertiary Education * Trade						2.944 (1.54)
Observations	588	588	588	588	588	582
No. of countries	98	98	98	98	98	97
No. of instruments	68	84	92	92	92	92
Hansen Test (p-value) <sup>1</sup>	0.19	0.24	0.44	0.50	0.43	0.65
AB 2 Test (p-value) <sup>2</sup>	0.46	0.40	0.36	0.41	0.30	0.39

Notes: Significance at the 10, 5, and 1 percent level is denoted by \*, \*\*, and \*\*\*, respectively. Estimation based on one-step system-GMM estimator with robust standard errors; corresponding z-values are reported in parentheses. Constant terms and time dummies are always included but not reported.

<sup>1</sup> Hansen-test of overidentification.

<sup>2</sup> Arellano-Bond-test that second-order autocorrelation in residuals is 0; first-order autocorrelation is always rejected (not reported).

In the next model (column 2 in Table 3), we add the infrastructure variable *Telecommunications* (main telephone lines per capita) as an explanatory variable. Adding this variable, which is important in the AfT context, does not fundamentally change the significance level, nor the coefficients of the variables of the first benchmark regression. The infrastructure variable itself has the expected positive sign and the coefficient is significant at the 10 % level.

The first two regressions show that the model employed explains differences in GDP per capita growth across countries and over time reasonably well. We then proceed in our analysis of whether an indirect effect on GDP per capita growth of the AfT variables through trade can be found. This indirect effect is captured by adding an interaction term between the AfT and the trade variable to the regression. The interaction term consists of the product of one AfT variable and the trade variable of the same period. If an indirect effect of the AfT variables exists, we expect a positive coefficient of the interaction term. The overall effect of the AfT variable, on the other hand, is the sum of its direct effect on GDP per capita growth and the indirect effect through trade. The overall effect is calculated by taking the coefficient of the AfT variable, the coefficient of the interaction term and the mean of the trade variable into account.<sup>9</sup>

In the following regressions we add, one by one, an interaction term between the trade variable and one AfT variable from the three main areas of interest: education, infrastructure and political institutions. In models 3 to 6, we add an interaction term between different education variables and the trade variable. In column 3, we start by adding the interaction term between *Total Education* and the trade variable. The variables of the augmented Solow model (*GDPpcgrowth* of the previous period, the initial level of GDP per capita, population growth, investment and the infrastructure variable) remain largely unchanged with respect to both coefficients and significance levels. The interaction term has the expected positive sign and is significant at the 5 % level, while the sign of the coefficient of trade and the education variable changed from positive to negative (the former at the 10 % significance level). However, the calculated overall effect of trade shows that the variable still has a positive influence on GDP per capita growth (with an overall effect of 0.0612).

In columns 4 to 6, the results for the three different components of the *Total Education* variable (*Primary*, *Secondary* and *Tertiary Education*) and their interaction terms with the trade variable are reported. For *Primary* and *Secondary Education*, we find similar results as for the aggregate *Total Education* variable. The coefficient of the interaction term is positive and significant at the 5 % level for *Primary Education* and at the 10 % level for *Secondary Education*. In both regressions the coefficient of the education variable is negative (in the case of *Primary Education* it is even significant at the 10 % level). Yet the overall effects of both trade and education are positive in all cases. In column 6, the results for the last education

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<sup>9</sup> F-test results show that *Trade* and the respective interaction terms together are statistically different from zero.

variable, measuring the average years of tertiary schooling of the population over 25, are reported. We obtain similar results for the variables of the benchmark as in the regression of the previous education variables. For the interaction term between *Tertiary Education* and *Trade*, however, we do not find a significant coefficient.

In columns 7 to 10 in Table 4, we add different infrastructure variables and their interaction terms with trade to the benchmark regression of column 1. For the four infrastructure variables *Telecommunications*, *Roads*, *Railways*, and *Power Generating Capacity*, the coefficients of the benchmark regression remain largely unchanged. But in all four regressions, the coefficients of the interaction terms between the different infrastructure variables and trade are not significant, meaning that we cannot establish an indirect impact of these variables on growth through trade.

In the last column, we add an indicator of the third area relevant for AfT, the quality of political institutions. We augment the benchmark regression with *Political Constraints* and the respective interaction term with the trade variable. Again, the results of the benchmark regression are not fundamentally altered. We obtain a positive and significant coefficient of the interaction term between *Political Constraints* and the trade variable. The coefficients of *Trade* and *Political Constraints* themselves are not found to be significant.

### **3.2 Discussion of the Results and Policy Implications**

Overall, we confirm the results reported by previous studies and find empirical evidence of a positive influence of trade on economic growth. In both benchmark regressions, the coefficient of the trade variable had a significant positive sign. This result lays the foundation for any Aid for Trade programme. Establishing this empirical connection justifies the endeavour of fostering economic growth through trade.

**Table 4: Determinants of GDP Per-capita Growth (Continued)**

Independent Variables	Dependant Variable: GDPpcgrowth				
	7	8	9	10	11
GDPpcgrowth (t-1)	0.147** (2.057)	0.174*** (2.637)	0.131** (2.108)	0.161** (2.16)	0.146** (2.075)
ln InitialGDPpc	-1.401*** (-3.320)	-1.484*** (-3.006)	-1.609*** (-3.626)	-1.610*** (-3.045)	-1.260** (-2.546)
Population Growth	-0.485*** (-12.06)	-0.495*** (-12.04)	-0.498*** (-12.33)	-0.390* (-1.728)	-0.476*** (-10.87)
ln Investment	2.214*** (2.888)	1.798** (2.557)	2.441*** (3.658)	1.566* (1.907)	1.974** (2.57)
Total Education	-0.15 (-0.676)	0.256 (0.946)	0.471 (1.267)	0.672* (1.954)	-0.237 (-0.986)
Trade	0.989* (1.882)	-2.574 (-0.836)	1.755 (0.453)	8.880* (1.655)	-1.225 (-1.205)
ln Telecommunications	0.659* (1.88)				0.848** (2.526)
ln Telecommunications * Trade	0.343 (1.199)				
ln Roads		0.23 (0.284)			
ln Roads * Trade		0.000262 (0.000427)			
ln Railways			-0.396 (-0.748)		
ln Railways * Trade			0.763 (1.35)		
ln Power Generating Capacity				0.774 (1.513)	
ln Power Generating Capacity * Trade				-0.493 (-1.101)	
Political Constraints					-0.198 (-1.178)
Political Constraints * Trade					0.427* (1.897)
Observations	588	506	496	578	580
No. of countries	98	95	84	97	97
No. of instruments	68	78	72	72	83
Hansen Test (p-value) <sup>1</sup>	0.30	0.40	0.53	0.40	0.19
AB 2 Test (p-value) <sup>2</sup>	0.30	0.49	0.31	0.45	0.24

Notes: See Table 3. Significance at the 10, 5, and 1 percent level is denoted by \*, \*\*, and \*\*\*, respectively.

Then, we focus in more detail on those areas that can be influenced by adequate AfT programmes. We have identified three different areas that are crucial for the AfT agenda: institutions, infrastructure and human capital. As most, if not all, of these variables clearly have a direct effect on economic development, we want to find out in which of these areas an indirect effect through trade on economic growth can be found. Identifying these areas is important for targeting AfT Programmes, as improving the conditions in these areas additionally leads indirectly, through the channel of trade, to higher economic development.

Our empirical results show a clear tendency towards the area of education and political institutions. We find a positive interaction term and a positive overall effect for the indicator of the total educational attainment level and the *Political Constraints* variable. Our results suggest that education and political institutions are the areas that should be targeted in AfT programmes.

To anybody involved in the development community, the results that education and institutions are important for growth will probably not come as a surprise. Therefore, it is important to highlight once again that our empirical research does not only show the direct effect of education and institutions leading to economic development. Instead, our results illustrate that the mentioned areas can lead to higher economic development through an additional indirect channel, that is, trade

Concentrating on the area of education in more detail, we find a positive and significant interaction term for the primary and secondary level of educational attainment, while for the tertiary level, these positive results cannot be obtained. This result would indicate that the indirect effects of education on GDP per capita growth are higher for the primary and secondary level than for the tertiary level. This result comes as a bit of a surprise, as higher levels of educational attainment are normally associated with higher economic development. But it should be stress that our results only hold true for the indirect effects through trade. The direct effects of the different educational levels can be quite different. Reasons for this result might be that the primary and secondary levels of education rather reflect the labour demand in the export orientated industries.

For the third area relevant for AfT, the infrastructure, we do not find any significant influence of the interaction term on growth. The number of telephone lines per capita, the network of paved roads or railways in relation to the population and the power generating capacity per capita seems not to have an indirect effect on growth through trade. However, the results regarding the influence of infrastructure should be treated with caution as it is quite difficult to find an adequate measure of both the quality and quantity of infrastructure. The indicators we have used only capture the existence of public infrastructure, but not their quality or the extent of their usage. More adequate data, for example, on the failure of telephone calls is available as well but only for a shorter time period and for less countries. With the indicators for the network of paved roads or railways, it is always problematical to take them relative to



population size or country size. Each measurement either overstates or understates the scope of infrastructure development for some countries. While in our analysis an indirect effect of infrastructure on trade has not been found, one should not draw the conclusion that such an effect does not exist. The shortcomings with respect to our data indicate that the influence and need of infrastructure in the context of AfT should rather be complemented with an extensive empirical analysis, for instance, at a country level.

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# Appendix

## Appendix A: Definition of Variables and Data Sources

Variable	Definition	Source
GDPpcgrowth	Real growth of Gross Domestic Product per capita in per cent	World Bank (2008b)
ln Initial GDPpc	Initial Real Gross Domestic Product per capita in constant 2000 US dollars (in logs)	World Bank (2008b)
Population Growth	Growth of total population	Heston, Summers and Aten (2006)
Investment	Investment share of real GDP (in logs)	Heston, Summers and Aten (2006)
Total Education	Average years of total schooling in the population of age 15 and over	Barro and Lee (2001)
Secondary Education	Average years of secondary schooling in the population of age 15 and over	Barro and Lee (2001)
Primary Education	Average years of primary schooling in the population of age 15 and over	Barro and Lee (2001)
Tertiary Education	Average years of tertiary schooling in the population of age 25 and over	Barro and Lee (2001)
Trade	Total exports and imports divided by Gross Domestic Product	World Bank (2008b) and Heston, Summers and Aten (2006)
Telecommunications	Total number of mainline phones divided by the total population (in logs)	World Bank (2008b)
Political Constraints	Polity IV, Political Constraints, scores 0 to 7; -66, -77, and -88 converted into 0	Centre for Systemic Peace (2008)
Roads	Total amount of paved roads divided by the total population (in logs)	World Bank (2008b)
Rails	Total amount of railways divided by the total population (in logs)	World Bank (2008b)
Power Generating Capacity	Total amount of kilowatt produced per capita (in logs)	World Bank (2008b)

## Appendix B: Descriptive Statistics, Period 1971-2005

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
GDPpcgrowth	686	1.81	2.98	-10.35	20.16
ln Initial GDPpc	686	7.62	1.60	4.44	10.59
Population Growth	686	1.81	1.88	-35.86	7.72
ln Investment	686	2.68	0.61	0.19	4.06
Total Education	686	5.47	2.80	0.28	12.13
Secondary Education	686	1.57	1.19	0.03	5.74
Primary Education	686	3.68	1.66	0.18	7.69
Tertiary Education	679	0.26	0.26	0.00	1.65
Trade	686	0.70	0.46	0.09	4.04
ln Telecommunications	686	-3.27	1.97	-8.60	-0.33
Political Constraints	676	4.51	2.30	0.00	7.00
ln Roads	589	-6.71	1.45	-10.35	-3.64
ln Railways	566	-8.62	1.23	-13.69	-5.35
ln Power Generating Capacity	674	-8.40	1.75	-13.00	-5.08

## Appendix C: Country Sample

*Algeria, Argentina, Australia, Austria, Bahrain, Bangladesh, Barbados, Belgium, Benin, Bolivia, Botswana, Brazil, Cameroon, Canada, Central African Republic, Chile, China, Colombia, Democratic Republic of Congo, Republic of Congo, Costa Rica, Cyprus, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Fiji, Finland, France, Gambia, Germany, Ghana, Greece, Guatemala, Guyana, Honduras, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Republic of Korea, Kuwait, Lesotho, Malawi, Malaysia, Mali, Mauritius, Mexico, Mozambique, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Rwanda, Senegal, Sierra Leone, Singapore, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Taiwan, Tanzania, Thailand, Togo, Trinidad & Tobago, Tunisia, Turkey, Uganda, United Kingdom, United States, Uruguay, Venezuela, Zambia, Zimbabwe*

Note: Developing countries in *italics*.