Effects of schooling levels on economic growth: time-series evidence from Guatemala

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Effects of Schooling Levels on Economic Growth: Time-Series Evidence from Guatemala[1]

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Abstract

This paper examines the determinants of economic growth in Guatemala, with a particular focus on the schooling level. Results based on an error-correction methodology show a better educated labour force has a positive and significant impact on economic growth. Consistent with micro evidence for Guatemala, primary education is more important than secondary and tertiary education. These findings are robust while changing the conditioning variables, controlling for data issues and endogeneity. Due to social and political conflict, the average per capita growth rate in Guatemala has been low.

Keywords: Economic growth, education, error-correction model, Guatemala.

JEL classification: C22, C51, O54.

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1. Introduction

This paper examines the determinants of economic growth in Guatemala between 1951-2002, with a particular focus on the contribution of different schooling levels. The interest is twofold.

First, to our knowledge, there are only a few studies that econometrically analyze growth patterns for individual developing countries and macroeconomic evidence on human capital and growth comes almost entirely from cross-country analysis. Single-country studies may be much more illuminating since they overcome the heterogeneity problem and take into account the unique historical information for each country. The cross-section focus may also be inadequate if returns to education or the quality of education differ substantially across countries. Indeed, the original motivation of studying economic growth focuses on the time-series dynamics of macroeconomic variables. Second, this study focuses on the contribution of different levels of education to growth.[2] This is an important aspect regarding the problems associated with measuring average years of schooling. Looking at education in a disaggregated way also proves more fruitful to the policy-maker from a public expenditure perspective, since it indicates how resources should be divided between different education levels. Finally, our empirical analysis is based on an error-correction methodology, deals with endogeneity, and explores data construction and robustness issues. All this may be relevant for future country case studies. For this paper, we are able to employ a unique time-series dataset for Guatemala for the period 1951-2002.

[2] In previous papers we focused on average schooling on growth effects in Guatemala, but without considering the contribution of different levels of schooling on aggregate growth (Loening, 2004,).

Including the introduction, this paper is organized into six sections. Section 2 assesses patterns of growth and some of the reasons that led to a low endowment of human capital in Guatemala. Section 3 discusses how to measure the contribution of human capital to growth and provides an overview of relevant empirical findings. Section 4 introduces the empirical methodology and presents the main results, disaggregated by education level. Section 5 tests the robustness of the results. Section 6 concludes.

2. Patterns of Growth in Guatemala

To understand Guatemala's growth patterns and the role of education its political and social history must be taken into account. With a multiethnic population of about 12.9 million and a per-capita GDP of US$2,600 in 2006, Guatemala is the largest economy in Central America. Average annual growth rates were only about 3.9 percent between 1951 and 2002 and in line with the neighbouring countries.[3] Due to rapid population growth, its per capita growth averaged only about 1.3 percent per year and implies it takes 53 years to double per capita income.

Guatemala's recent growth experience can be divided into three broad episodes. Figure 1 visualizes annual GDP growth from 1951-2003, where selected parallel historical events are given from Luján (2000). Table 1 presents the average output growth rates of primary, industry and service sectors for the period 1951-2003. The growth rates of the primary sectors, which employ the majority of the rural and poor people, lagged behind other sectors for the entire time period. By contrast, in particular for the last decade, the growing sectors were electricity, communications

[3] Growth has been slightly higher in Costa Rica (4.7 percent) but lower in Honduras (3.7 percent), El Salvador (3.2 percent) and Nicaragua (2.1 percent).

and banking. Until approximately 1975, Guatemala appears to have had a reasonable growth performance, followed by a remarkable slowdown for the later periods. However, this requires a closer examination.

During 1951-1975, Guatemala maintained reasonable growth rates. Ever since the coup in 1954, military governments were repeatedly in power, sometimes through fraudulent elections and sometimes by *coup d'états*. In terms of its growth performance, this first era is sometimes referred to as the 'golden period' but the denomination is misleading because the structural imbalances of the economy remained unchanged and caused civil strife. Annual growth rates were highly volatile due to dependence on agricultural exports and political unrest. For example, a new constitution was drawn up in 1956 and it was preparing to enter into the Central American Common Market (MCCA) in 1963.[4] Figure 1 suggests that the civil war's guerrilla activities, starting around 1960, appeared to have an impact on the short-run growth.

[Figure 1 here]

The second period started after the deterioration of the terms of trade and the international oil crisis. In 1976, a major earthquake affected Guatemala. After 1977, social tensions lead to a full-scale civil war, with genocidal proportions, and in the early 1980s growth declined dramatically. Apart from causing immense human sorrow, these events destroyed human life and physical capital and imposed high costs for long-run growth. Chamarbagwala and Morán (2010) provide mirco evidence how badly the 36-year-long civil war civil war affected human capital accumulation, especially among the Mayan population.

[4] See de la Ossa (2000) for a review of the Central American integration process for 1950-1999. Eventually Guatemala has joined the new Central American Free Trade Agreement (CAFTA) in 2006.

The third episode begins approximately in 1985 when democracy was restored, albeit with civilian governments patronized by the generals. Although growth rates recovered, they followed a stagnant pattern. A cornerstone in economic and social developments was the signing of the UN sponsored agreement of a 'Firm and Lasting Peace' in December 1996, which was the formal end to the civil war. Since then Guatemala has made progress by increasing investments in infrastructure and human capital, improved public financial management and tax revenues. During the recent decades, Guatemala was perhaps affected by electoral cycles, although López-Cálix (2002) found only weak evidence for this hypothesis. Therefore, GDP growth has declined continually since 1999 but the reasons are not clearly understood. It is uncertain whether this represents a decrease in Guatemala's trend growth or a prolonged cyclical downturn. It is reasonable to argue that this decline is partly associated with high levels of violence, kidnappings (including the central bank governor) and social unrest. In addition, Guatemala scores poorly on most governance indicators, particularly those for corruption, the rule of law, justice system, and political stability. These factors ultimately seem to have damaged the climate for growth and investment.[5]

Nevertheless, somewhat paradoxically, Guatemala has experienced relative macroeconomic stability in the recent decades. Guatemala has a low level of external indebtedness, inflation has been held back, and after a process of uncompleted structural reforms, the economy is now fairly open and with low levels of protection. Thus, contrary to other Latin American countries, macroeconomic mismanagement may not be regarded as the main factor to understand Guatemala's modest

[5] The World Bank (2009) and Larrain (2006) analyze these issues in more detail.

performance in terms of per capita growth. Rather, other issues, e.g. a low level of human capital, could have undermined Guatemala's growth patterns.

The current level of the human capital base is essentially a product of past agricultural growth and the anti-distributional policies. The World Bank (2003) and UNDP (2002) document that insufficient cheap labor, in particular for coffee, was the main barrier for the expansion of export crops during earlier periods. Hence, in order to create a low-wage labor force, the *campesino* and indigenous society was excluded from education. The plantation economy that resulted provided little incentives to accumulate human capital. Historically, the low level of schooling is also an outcome of a discriminatory education system and this exists even today.

Despite some improvements over time, Table 2 shows that the country still performs poorly for indicators of education and health, and ranks highest among states in the region for child malnutrition. In addition, Guatemala spends less on education than any other country in the region. Based on household survey data comparing the education level of age cohorts, the Inter-American Development Bank (2001) finds that the educational gap between Guatemala and other Latin American countries is widening. Historically, it may be that a certain degree of development and growth in Guatemala was attainable with a skilled elite and a large amount of unskilled workers. Since the economy has diversified over time and is now less dependent on agriculture than before (Segovia and Lardé 2002), the past exclusionary education policies may present an obstacle for future growth. On the micro level, there is evidence suggesting that in addition to perceived high levels of corruption insufficient human capital constitutes a constraint for production. A survey by Grupo de Servicios de Información (1999) indicates that for all firms the quality of skills ranks as the second most important constraint. For small firms, the quality of skills is the main production constraint.

[Table 1 here]

[Table 2 here]

3. Measuring the Contribution of Education to Growth

The existing literature contains a number of rationales for the inclusion of human capital in models of economic growth. According to Sianesi and van Reenen (2003), the two main macro approaches are the augmented Solow model of Mankiw et al. (1992) and the endogenous growth models. While endogenous growth models are appropriate for estimation with a large number of observations in the cross-country data sets, the Solow model is useful for estimation with country specific data, because time series observations are generally limited.

One way to estimate the impact of education on growth is to adapt the Mankiw et al. extended version of the Solow (1956) model. The augmented version extends the basic framework to allow human capital as an extra input. In particular Mankiw et al. show that traditional growth theory can accommodate human capital to provide a reasonable approximation for empirical analysis. At the economy-wide level, it may also take into account human capital externalities. Still, one of the key insights is that the factor accumulation affects the level of income, but per se is does not change the long-run growth. Long-run growth depends rather on growth in technological progress. Human capital accumulation may therefore have only a short to medium term impact on the growth rate. Nevertheless, rates of accumulation are expected to have explanatory power for growth rates during the transition to an eventual equilibrium growth path. In particular, considering the case of Guatemala, presumably far away from a steady state, consideration of transition could open up the possibility of assessing the role of education for growth within this framework. In addition, since the 'short run' in the context of growth theory is often thought of in terms of decades, these effects can be worthwhile policy objectives. It is in this sense we shall use the term growth rate in this paper.

4. Time-Series Evidence for Guatemala

This section presents the main empirical evidence regarding the relationship between education and growth in Guatemala. We first introduce the empirical methodology. We then report the findings for average years of schooling and growth. Given the apparent shortcoming of aggregate measurements of human capital, we examine separately the effects of primary, secondary and tertiary schooling on growth. Finally, we compare the returns to education at the macro level with the microeconomic evidence. A description of our main data sources is in Appendix 2.

Basic Methodology

The empirical methodology for the following sections is based on the human capital augmented growth model of Mankiw et al. (1992). This model considers human capital as an independent factor of production. It can be represented in a Cobb-Douglas production function with constant returns to scale in a different form than in Mankiw et al. by treating human capital as an index of the quality of labour as follows:

$$Y_t = A_t K_t^{\alpha} (H_t \times L_t)^{\beta} \quad (1)$$

where Y represents output and A is the level of technology or total factor productivity. K, H and L are physical capital, human capital and employment, respectively, and $(\alpha+\beta)=1$. Equation (1) can be converted into its intensive form by dividing the variables with employment and its log-liner specification is:

(2) $$\log y_t = \log A_t + \alpha \cdot \log k_t + \beta \cdot \log H_t + u_t$$

where the lower case variables $y = Y/L$ and $k = K/L$ are output and physical capital in intensive terms with H as the average years of schooling, a proxy measuring human capital as in Mankiw et al. At first glance, the formula already appears suitable for estimation. However, some problems arise since it is well known that most macroeconomic time series contain unit roots and that the regression of one non-stationary series on another is likely to yield spurious results. As reported in Appendix 1, the data for Guatemala is no exception. The estimation bias can be removed by transforming the time series to stationarity. This can be done by first differencing. In any case, this will create its own problems, notably because of the risk of losing valuable information on the long-run relationships of the variables.

One approach to dealing with this dilemma is to employ an error-correction model which combines long-run information with a short-run adjustment mechanism. This methodology has been used successfully in alternative growth studies. Examples of this are Nehru and Dareshwar (1994), Morales (1998), and Bassanini and Scarpetta (2001). Recently Rao et al. (2010) argued that equations with non-stationary variables can be estimated with the classical methods if they are transformed into error correction forms. Banerjee et al. (1993) also show that the generalized one-step error-correction model is a transformation of an autoregressive distributed lag model. As such, it can be used to estimate relationships among non-stationary processes. Based on Hendry's (1995) concept of general-to-specific modeling, the error-correction model of the human capital augmented production function for Guatemala can be specified as follows.[6]

$$\text{(3)} \qquad \begin{aligned} \Delta \log y_t = & -\gamma_3(\log y_{t-1} - \alpha \log k_{t-1} - \beta \log H_{t-1} - \log A_{t-1}) \\ & + \gamma_1 \Delta \log k_t + \gamma_2 \Delta \log k_{t-1} + u_t \end{aligned}$$

As it stands, this equation can be estimated with the non-linear least squares (NLLS) or with the two-stage non-linear instrumental variables (2SNL-IV) to minimise the bias due to the endogeneity of some explanatory variables. Banerjee et al. (1998) argue that a significant estimate of the adjustment coefficient (γ_3) serves as a test for cointegration. Notice that the technology parameter, *A*, can be assumed to change overtime as a function of different variables, *Z*:

$$\text{(4)} \qquad \log A_t = f(Z_t)$$

where in its simplest formulation the technology level is proxied by a constant term, *c*, and a series of dummy variables. In a later section, proxy variables with respect to growth of trade openness, bad governance and other variables will be included in the equation. The majority of the following regressions include three dummies. First, a 1963 impulse dummy (D63) captures a positive one-off effect stemming from expectations regarding the Central American Common Market (MCCA). Second, a 1982 impulse dummy (D82) takes into account a negative one-off effect stemming from the peak of internal war. Third, a 1977 step dummy (D77) which models a structural change in the long-run relationship of the variables. In fact, the 1977 dummy is always negative, very significant, and most likely corrects for the

[6] Additional lagged changes of the variables can be added to equation (3). To keep the notation simple these are not shown. In our subsequent empirical work these additional lagged changes of the variables are also found to be insignificant.

deviations resulting from the civil strife. Interestingly, this finding is consistent with the quality index of the capital stock series showing a decreasing trend since 1977. [7]

Table 3 shows the results for equation (3) with the three dummy variables. In column (1) NLLS and in column (2) 2SNL-IV estimates are reported and both give similar estimates. The adjusted R^2 in these two estimates are high and indicates a good data fit. The χ^2 test statistics do not indicate any serial correlation, functional form misspecification, non-normality and heteroscedasticity in the residuals. If not mentioned otherwise, these properties apply equally to subsequent regressions. The adjustment coefficient is highly significant and suggests a moderate speed of adjustment towards the long-run growth path, equal to about 25 percent of the deviations per year. After any specific shock to the economy it would, on the average, take approximately 10 years to reach 90 percent of the steady state level of output. Therefore, during the transition period there would be positive and higher growth rates for more than a decade. The high significance level of the adjustment coefficient suggests a cointegrating relationship of the variables.

The results are satisfactory considering the distortions caused by the internal military conflict and the simplicity of the assumptions used to construct the time series in the context of data uncertainties. At first sight, this seems astonishing. However, the good performance of the model may be due to the small size of the economy, and that the overall data uncertainties are not as severe as is commonly believed. The most striking result is that human capital, as measured by average years of schooling, has a highly significant, positive and strong impact on level of output

[7] A sparse inclusion of dummy variables is the preferred econometric formulation. Other settings will be described in the following sections. It is important to emphasize that the basic results are not sensitive to the dummy variables. That is, the omission of the impulse dummies (1963 and 1982) does have little impact on the qualitative results. However, it is important to model the structural break.

and therefore on the medium term growth rate. Compared to the NLLS estimate in column (1), the quality of the results does not vary much with the IV estimation in column (2). The estimating parameters are in both cases significantly different from zero and the regressions, as test statistics indicate, show a satisfactory performance. However, the absolute value of the adjustment coefficient is a bit higher and changes in all other coefficients are marginal. Although the coefficient of human capital is slightly less than that of physical capital, the hypothesis that both coefficients are not significantly different from their stylised value of one-third, as in Mankiw et al. could not be rejected by the Wald test. The computed Wald test statistic, with the p-value in the square brackets, is $\chi^2 = 3.033[0.22]$. This implies that physical and human capital and labour have equal effects on the level of output and the short to medium term growth rates.

[Table 3 here]

Schooling and Growth by Education Level

Using education data by levels may be preferable for a number of reasons. In particular, the growth impact of different forms of educational capital may vary, and it is important from a public expenditure perspective to understand the contribution of each level to growth. Columns 1-6 in Table 4 present the results of the production function augmented for human capital where the education level of the labour force viz. primary, secondary and tertiary, enters separately into the estimation. The shares of the labor force with primary, secondary and tertiary education are used to multiply the years of schooling. Ideally, one would also include primary, secondary and tertiary education into the same equation in order to assess their joint impact on growth. However, due to strong colinearity, none of the three coefficients were significant and the estimation only supports the inclusion of one education level. Notice that the estimates include a time trend starting in 1985, the year of Guatemala's transition to civilian rule. The inclusion of the trend variable was motivated to avoid serial correlation in the residuals. Although its coefficient is not significant in the equations for tertiary education, reestimates without trend did not have an impact on the magnitude of coefficients. These are not reported to conserve space.

Table 4 presents both NLLS and 2SNL-IV estimates with the three types of schooling variables. The summary statistics are impressive. The endogeneity problem seems to be more pronounced for physical capital in the equations for primary education, where its coefficient has increased from 0.445 in column (1) to 0.566 in column (2). Although the share of profits in column (2) is the highest of all other estimates, it is not significantly different from the stylised value of one-third. The Wald test for this hypothesis is not rejected at the 5% level. The computed test statistic with the p-value in the square brackets is 1.513[.219]. However, the qualitative results do not vary substantially. In all specifications the schooling variables are highly significant and positively correlated with growth. Regarding the long-run elasticities, the accumulation of primary schooling appears to be most important for growth with an output elasticity of about 0.4, followed by secondary schooling with an elasticity of about 0.2 and tertiary schooling with an elasticity of about 0.1. This finding should *not* be interpreted as implying that other levels are unimportant. This is particularly true given the tight connections between the various forms of educational capital and the retrospective character of the empirics.

Nevertheless, the evidence is in line with the limited cross-country studies on this topic. Gemmel (1996), Petrakis and Stamatakis (2002) and Papageorgiou (2003) suggest that the importance of post-primary education increases with the level of development. Similarly, de Ferranti et al. (2002) argue that in countries classified as adopters, such as Guatemala, policies should first focus on a critical threshold level of primary schooling, coupled with open trade policies. The intuition is that different stages of technological transition require distinct policy priorities. A sufficient coverage and quality of primary education are regarded as the minimum prerequisite to adopt technologies. By contrast, in countries where basic skill requirements are fulfilled and firms are making significant adaptations or innovations, the creation of more specialized skills ought to be the priority. In addition, the results here partially confirm the earlier micro-level evidence for Guatemala.[8]

[Table 4 here]

Mincerian Human Capital Specification

An important question is how the effect of schooling at the macro level compares with the microeconomic evidence. The macro returns could be higher because of externalities from education. For example, if post-primary schooling leads to technological progress that is not captured in the private returns to education, or if education produces externalities in the form of the reduction of crime, more informed political decisions, better health and so on. To reconcile the macro effect of schooling with the micro level, Cohen and Soto (2007) estimate the following production function:

[8] For Guatemala, Psacharopoulos and others have extensively investigated the returns to schooling, sometimes by level of education. Such exercises are summarized in Psacharopoulos and Patrinos (2002), Haeussler (1993) and World Bank (1995). The studies generally report high private returns to primary schooling, but are merely based on ENS (1989) or earlier data, and typically do not address sample selection bias.

(5) $$Y_t = A_t K_t^{\alpha} HM_t^{(1-\alpha)}$$

where Y is output, A total factor productivity, K physical capital, and HM human capital. As first suggested by Bils and Klenow (2000), the micro evidence derived from a log-linear Mincer (1974) formulation can be used to specify the aggregate human capital stock as follows:

(6) $$HM_t = e^{\theta H_t} L_t$$

where HM is the human capital, H is average years of schooling and θ is the return to education. Instead of using employment in the simple production function, equation (5) can be interpreted as using skill adjusted employment. Therefore, the implied production function, without time subscripts for simplicity, is $Y = AK^{\alpha}(e^{\theta H}L)^{(1-\alpha)}$. This Mincerian approach has become popular in the literature since the work of Bils and Klenow. The specification is a straightforward way of incorporating human capital into the production function consistent with the standard semi-logarithmic formulation for estimating returns to schooling at the micro level. It remains of considerable interest since an empirical estimate provides a way of either confirming or rejecting the importance of education suggested by micro studies. For the Guatemalan case, the econometric specification is similar to the previous equations (1) to (3) and the error correction form of the equation for estimation, similar to in Table 3, is as follows.

(7) $$\begin{aligned}\Delta \log y_t &= -\gamma_3(\log y_{t-1} - \alpha \log k_{t-1} - (1-\alpha)e^{\theta H_{t-1}} - \delta_{77}D77_{t-1} - \delta_{63}D63_{t-1} - \delta_{82}D82_{t-1}) \\ &\quad + \gamma_1 \Delta \log k_t + \gamma_2 \Delta \log k_{t-1} + u_t\end{aligned}$$

In principle, this approach would also allow the productivity effect of schooling to be differentiated by education level, as mentioned by Wößmann (2003). Unfortunately, the results here were found unstable for disaggregated education data. Insofar, the specification provides an attractive way for comparing macro and micro evidence on the returns to schooling, but in a time series context tends to produce fragile parameter estimates. Nevertheless, when using aggregated data on human capital the regressions perform quite satisfactorily. Table 5 presents the results and all the summary statistics are impressive. Controlling for endogeneity does not distort the empirics. In the IV estimates in column (2) of Table 5, one additional year of schooling increases income per worker by approximately 13 percent. This estimate is not much different from 13.5% estimate in column (1) with NLLS, implying an insignificant endogeneity bias. This number suggests that the macro return to schooling in Guatemala is rather high, but it compares favourably with earlier microeconomic evidence. For example, the World Bank (1995) reports a private return to schooling of 14.9 percent for Guatemala. There is evidence for much lower returns in the informal sectors and for decreasing patterns over time, but the magnitude of the coefficient is echoed in Funkhouser (1997). An estimate from Haeussler (1993) based on 1989 survey and Ministry of Education data suggests that, depending on the schooling level and underlying assumptions, the social return to schooling lies in a band between 13-19 percent. Our estimate is close to the lower bound. Finally, these results also confirm the cross-country evidence from Cohen and Soto (2007). They essentially find that in macro and micro regressions the effect of education on income is of similar magnitude.

[Table 5 here]

5. Robustness Check

This section seeks to answer some questions such as how much confidence should be placed on the previous results, if the previous findings can be used to derive firm policy conclusions and whether the conditioning information set cause the schooling coefficients to change. To answer these questions, we proceed as follows. Given the distortions in the economy by the civil strife and other events, it is imperative to evaluate the stability of the coefficients. In order to test for instability, we first evaluate parameter stability of the basic specification of the human capital augmented production function of column (1) of Table-3, using the CUSUM and CUSUMSQ tests. These plots are in Figure-1.[9] Second, we have used quality adjusted capital stock to see if there is any significant change in the estimates. Third, alternative measures of human capital are used to estimate this basic production function and then the Mincer equation. Finally, addition variables that may add to the long run or the medium term growth rate have been added to estimate the basic production function and the Mincer equation. It can be seen from Figure 2 that the residuals are within the two boundary lines indicating structural stability of the basic production function.

[Figure 2 here]

We estimated first the basic production function of Table-3 by adjusting the capital stock for its quality and the estimates are in column (1) of Table-6. To conserve space only 2SNL-IV estimates are reported for all the equations in this table. It can be seen that this did not make any significant qualitative changes to the estimates. Next, we have used alternative measures of human capital by Barro and Lee (2001) and Cohen, D. and M. Soto (2007) to estimate the basic production function and the Mincer equation. These estimates are reported in columns (2) to (5) of Table-6. It can be seen that the coefficients of human capital are significant. Although these reestimated coefficients have slightly changed, there are no major changes in the estimates of the other coefficients and their significance. In the Mincer equation with the Barro and Lee measure of human capital in column, the rate of

[9]We also examined the plots of coefficients from recursive least squares estimates. This allows a year-by-year comparison of the coefficients. No coefficient crossed the two standard error bounds. These plots are not reported to conserve space but may be obtained from us.

return to education is 19 percent compared to 13 percent with our aggregate measure in Table 5. [10]

Finally, the basic production function and the Mincer equation are estimated by augmenting them with additional variables that are expected to have growth effects in the long or short to medium terms. These additional variables are trade openness, terms of trade, imported capital goods, life expectancy and military expenditure, which may also serve as a proxy for bad governance in Guatemala. The justification for including these variables is generally well known in the applied growth literature and is as follows:

Trade Openness: Apart from comparative–advantage arguments, openness expands potential markets, facilitates the diffusion of technological innovations, improves managerial practices and promotes domestic competition, all of which increase efficiency.

Terms of Trade: Improvement in the terms of trade, that is, a higher growth of the ratio of export prices to import prices, seem to enhance economic growth by increasing the ability to pay for essential imports of capital equipment and raw materials.

Imported Capital: Lee (1995) emphasizes that developing countries can increase the efficiency of capital accumulation and thereby the rate of growth by importing relatively cheap foreign capital goods from higher income countries. The

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[10] Alternative Schooling Data: The most interesting sensitive test concerns the validity of the conclusions on the importance of human capital to growth. The data used for the Barro and Lee (2001) and Cohen and Soto (2007) measures are interpolated. In both estimates human capital, as measured by average years of schooling, is robustly correlated with growth. Given the interpolated nature of these sources, a too strong interpretation of the associated changes makes little sense. Insofar, the sign and significance of the variables are more important than their magnitude. All in all, employing alternative data on human capital confirms the earlier conclusions about the importance of education on growth.

ratio of capital imports to total investment is used as a proxy variable for the efficiency of capital accumulation.

Life Expectancy: Given the incomplete nature of education to proxy for human capital, a look at the effect of the health status yields important insights. Barro (2001) suggests that this variable may have a strong impact on growth because it may proxy for features other than health, such as social capital, better work habits and a higher level of skill. The estimates of these growth effects, if significant, support the view that human capital policies in Guatemala should place a strong emphasis on the health status of the population. This finding is equally echoed by the World Bank (2003) that places Guatemala among the worst performers in terms of health outcome in Latin America, and particular poor in child nutrition.

Military Expenditure: Given the strong influence of military rule in Guatemala's recent history, it is imperative to discuss the role of military expenditure on growth. According to Deger and Sen (1995), the defence sector can take skilled labour away from civilian production, but it can also train workers. It could crowd out resources for investment and impact negatively on the efficiency of resource allocation, but also provide positive externalities for the civilian sector, such as infrastructure development. It can stipulate civil strife, but also generate an increase in national security and strengthen property rights. This issue is particularly important since in the light of Guatemala's low tax burden, military expenditures will necessarily be met at the expense of other government services, such as education and health.

Given the historical and political context of Guatemala, it is a priori hard to believe that military expenditure plays a positive role on economic growth. According to the Commission for Historical Clarification (1999) an overwhelming number of violent actions during the civil war was attributed to members of the army. In addition, forced displacement and mandatory civil defence patrols (*Patrullas de Autodefensa Civil*—PACs) diverted a significant share of the economically active population from productive activities.

When all these additional variables are assumed to have long run growth effects, except the negative coefficient for military expenditure, none of the other coefficients were significant. [11]Therefore, the basic production function and the Mincer equation are reestimated only with military expenditure as an additional growth factor and reported in columns (6) to (7) in Table-6.[12] Estimates of both equations are satisfactory and their summary statistics are similar to the ones without this additional variable. Military expenditure has only a very small but significant growth effect in the basic equation and its coefficient, although negative, is insignificant in the Mincer equation. Therefore, estimates of other coefficients, with and without this variable did not show any significant changes.

[Table 6 here]

6. Conclusions

Since various robustness tests revealed that the relationship of human capital and growth is stable, we may draw the following conclusions. In the light of Guatemala's recent history, it does not come as a big surprise that military expenditure has somewhat hampered growth. Human capital has a highly significant and positive

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[11] Also Reitschuler and Loening (2005) using a threshold regression model find negative impacts of defense expenditures on growth in Guatemala.

[12] We tested also if these variables have any short to medium term growth effects but found that the coefficients of their current and one period lagged changes were insignificant.

impact on growth in Guatemala. The stability of the error-correction model with respect to data issues and endogeneity concerns are the main reasons for confidence in the overall results.

The importance of human capital is substantial. An increase by 1 percentage point of average years of schooling would permanently raise the level of output by about 0.33 percent and therefore also the transitional growth rate for a few years. This effect is of similar magnitude to that in micro studies. A disaggregated analysis by level of education reveals that primary schooling is most important for its effects on the level of output, followed by secondary schooling. Over the past decades, it appears that general education and basic technical skills have been the main determinants for the diffusion of technological innovations

The paper contains additional findings of interest, which ultimately point towards the importance of an institutional and political environment conducive to growth. They can be summarized as follows. First, Guatemala's growth process was accompanied by the exclusion of large parts of society from wealth and by underlying social conflict. The growth rates of the sectors that employ the poor and rural people lagged behind other sectors of the economy. Extreme social imbalances and weak institutions for conflict management gave rise to an internal military conflict that imposed high costs for long-run growth. Regarding Guatemala's future growth prospects, a key factor for reducing the vulnerability of the economy to external shocks is to reduce poverty and to strengthen institutions.

Second, mean education of the labor force has increased over time, although it suffered from the civil strife. The average rate of return for the aggregate schooling is between 13 to 19 percent. The attention to education since the Peace Accords has only compensated the loss of human capital caused by the civil war, but does not represent a major improvement regarding the long-run growth of human capital. This means that a significant effort is needed to strengthen the country's human capital base.

Finally, there is evidence of a missing complementarity between Guatemala's skills and its technology base. That is, the quality of Guatemala's physical capital stock decreased by about 20 percent and this seems to have reduced the elasticity of capital by about 10 percent (0.04/0.44). Prominent explanations for this decline are the destructive impact of the civil war, and an unfavorable investment climate due to an unstable policy environment, security issues, and a lack of what is commonly perceived as good governance. The apparent gap between the evolution of quality of labor and physical capital could be a key factor for the relatively low output growth rates during the past decade. Decreased efficiency in capital accumulation also tends to reduce the returns to education, in particular for primary schooling. Hence, measures to stimulate investment and imports of foreign capital goods—for example through regional integration and by improving the investment climate—are important complementary factors to human capital policies.

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Appendix

Appendix 1. Guatemala: Augmented Dickey-Fuller Test for Unit Roots

	ADF test statistic	
Variables	Levels	First differences
log *y*	-2.24	-4.87**
log *k*	-1.85	-4.36**
log *k* (4 percent depreciation)	-1.76	-4.38**
log *k* (disaggregated estimate)	-1.33	-2.99*
log *k* (quality adjusted)	-2.04	-2.97*
log *h*	-0.23	-2.97*
log *h* (Barro and Lee)	-0.72	-4.76**
log *h* (Cohen and Soto)	-1.49	-4.54**
log primary schooling	-1.18	-3.37**
log secondary schooling	-0.07	-3.23**
log tertiary schooling	-1.35	-4.33**
log life expectancy	-2.41	-4.25**
log trade volume/GDP	-1.91	-4.21**
log terms of trade	-2.03	-5.20**
log capital imports/investment	-2.05	-4.74**
log military expenditure/GDP	-1.45	-5.17**

** (*) Rejects the hypothesis of a unit root at the 1 (5) percent significance level assuming 1 lag in the test equation, constant included. The MacKinnon critical values are –3.59 (-2.93) at the 1 (5) percent level.

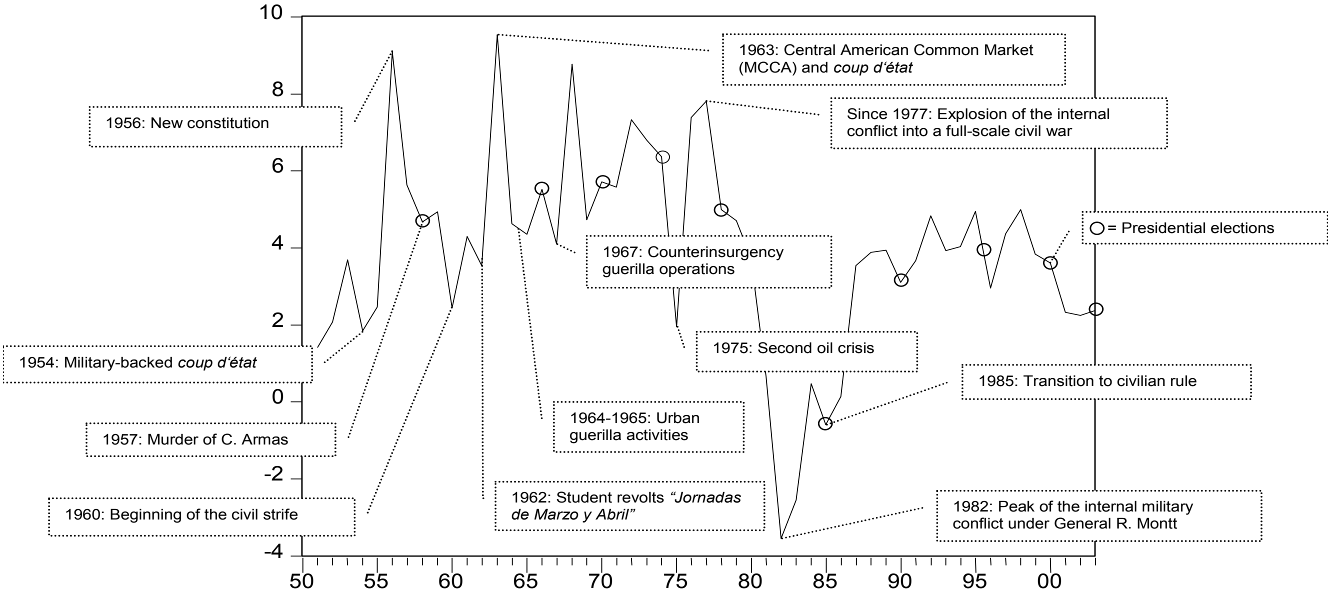
Appendix 2. Guatemala: Data Sources of Time Series

Variables	Abréviation	Source
Gross domestic product (GDP) (in 1958 Quetzals)	Y	Banco de Guatemala.
Capital stock (in 1958 Quetzals)	K	Perpetual inventory estimates, see text.
Gross fixed capital formation (in 1958 Quetzals)	I	Banco de Guatemala. Aggregated data is for 1950-2002, disaggregated information applies for 1970-2002.
Annual rental rates	$v_{i,t}$	Calculations are based on Morán and Valle (2002) data set for implicit price estimates, and Banco de Guatemala for disaggregated gross fixed capital formation and real interest rates.
Physical capital quality index	Zq zzq	Estimated, see Loening (2005). =1 up to 1970 extrapolated
Imports (in 1958 Quetzals)	IM	Banco de Guatemala.
Imported capital goods (in 1958 Quetzals)	IM_{cap}	Banco de Guatemala.
Exports (in 1958 Quetzals)	EX	Banco de Guatemala.
Commodity terms of trade (1970=100)	ToT	CEPAL and CIEN (Centro de Investigaciones Económicas Nacionales).
Military expenditure (in 1958 Quetzals)	MIL_{exp}	Ministry of Defense expenditures are calculated from Banco de Guatemala, as reported in *Memorias de Labores del Banco Central*. The data compares favorably with information from the Stockholm International Peace Research Institute (SIPRI).
Life expectancy at birth (years)		World Bank (2002).
Average schooling (years)	h	Perpetual inventory estimates, see Loening (2005)
Participation of primary, secondary and tertiary education in labor force	hr_{pri} hr_{sec} hr_{ter}	Perpetual inventory estimates, see Loening (2005).
Labor force, total	L	Derived from the number of private contributors to the IGSS, see text. Data for 1960-2002 is taken from Banco de Guatemala (2003). Data for 1955-1959 is obtained directly from IGSS. Missing values for 1950-1954 were derived from SEGEPLAN (1978).
Labor quality index	hq	Author's calculations, see text. The weights are taken from Table 6, columns 2, 4 and 6.
Primary and secondary	PRI	For 1960-1990 UNESCO estimates as reported in

gross enrollment ratios	SEC	World Bank (2002). For 1991-2002 Ministerio de Educación (various years) and UNDP (2002). Primary gross enrollment ratios are that of *nivel primaria*. Secondary gross enrollment ratios are that of *nivel básico*. Missing values were completed with information provided in UNESCO (various), Mitchell (1998) and Ministerio de Educación and SEGEPLAN (1980).
Tertiary gross enrollment ratio	TER	For 1960-1987 UNESCO estimates as reported in World Bank (2002). Missing values were either interpolated or completed with information provided in Mitchell (1998), UNESCO (1966) and UNESCO (various). For 1988-2002 ratio of students at San Carlos University (USAC) to the number of persons aged 20-24, as reported in Global Info Group (1999) and UNDP (2003a).

Tables and Figures

Figure 1. Guatemala: Growth, Social Conflict and Politics, 1951-2003



Source: Authors' elaboration based on data from Banco de Guatemala. Historical events are taken from Luján (2000).

Table1. Guatemala: Sectoral Output Growth, 1951-2003 (in percent)

Sector	1951-03	1951-75	1976-85	1986-03
Primary	3.2	4.2	1.6	2.7
Agriculture, forestry, livestock and fishing	3.1	4.2	1.5	2.6
Mining and quarrying	8.1	3.3	16.9	9.5
Industry	4.3	5.6	2.8	3.2
Manufacturing	4.0	5.9	2.4	2.2
Construction	4.0	3.9	5.4	3.9
Gas, electricity and water	8.4	9.7	6.0	8.2
Services	4.2	5.0	2.5	3.9
Wholesale and trade	3.8	5.0	1.3	3.3
Transport, storage and communications	6.2	7.5	3.4	5.9
Banking	6.9	8.3	6.1	5.3
Public administration and defense	4.6	4.5	5.6	4.5
Other services	3.4	4.2	2.4	2.9
Total GDP growth	3.9	4.9	2.3	3.5

Source: Authors' calculations based on data from Banco de Guatemala.

Table 2. Guatemala, Central and Latin America: Comparison of Human Capital Indicators, 1998-2002

Indicator	Guatemala	Nicaragua	Honduras	El Salvador	Costa Rica	México	Latin America
Public spending on education (in percent of GDP) (average 1998-2000) c/	1.7	5.0	4.0	2.3	5.7	4.4	NA
Average years of schooling (2000) b/	4.8	6.3	5.3	5.1	6.7	7.9	7.3
Net primary school enrollment (in percent) (2000-2001) c/	84	81	88	81	91	103	97
Net secondary school enrolment (in percent) (2000-2001) c/	26	36	N.D.	39	49	60	64
Adult illiteracy (in percent of total population) (2002) a/	30.1	32.9	23.8	20.3	4.2	8.3	10.5
Infant mortality (per 1000 births) (2001) a/	43	36	31	33	9	24	28
Life expectancy at birth (years) (2002) a/	65.5	68.7	66.1	70.1	77.6	73.6	70.7

Source: a/ World Bank (2002). b/ Cohen and Soto (2007). c/ UNDP (2003b). NA = no data available.

Table 1. Guatemala: Production Function with Average Years of Schooling, 1951-2002

$\Delta \log y_t = -\gamma_3(\log y_{t-1} - \alpha \log k_{t-1} - \beta \log H_{t-1} - \delta_{77} D77_{t-1} - \delta_{63} D63_{t-1} - \delta_{82} D82_{t-1}) + \gamma_1 \Delta \log k_t + \gamma_2 \Delta \log k_{t-1} + u_t$		
	NLLS	2SNLLS-IV [a/]
Explanatory variables	(1)	(2)
Constant	-0.3193*** (10.18)	-0.3198*** (10.72)
$\log y_{t-1}$	-0.2414z*** (5.87)	-0.2966*** (5.83)
$\log k_{t-1}$	0.4437*** (5.79)	0.4394*** (5.62)
$\log H_{t-1}$	0.3512*** (7.70)	0.3505*** (8.63)
$D77$	-0.1707*** (-5.44)	-0.1676*** (5.99)
$D63$	0.2349** (3.77)	0.1958*** (3.83)
$D82$	-0.3184*** (3.57)	-0.2305** (2.60)
$\Delta \log k_t$	0.8711*** (30.16)	0.8740*** (13.16)
$\Delta \log k_{t-1}$	0.1204*** (3.28)	0.1140* (1.96)
$\overline{R}^2$	0.964	0.964
Sargan IV test (χ^2)	----	4.132[0.13]
S.E. of regression	0.012	0.012
χ^2_{sc}	0.088[0.77]	0.010 [0.92]
χ^2_{ff}	0.878[0.349]	0.494[0.48]
χ^2_{N}	1.863[0.394]	1.330 [0.514]
χ^2_{HS}	0.337[0.562]	0.015[0.90]
N	51	50

a/ Two period lagged independent variables are used as instruments. The χ^2 tests with p-values in square brackets are for the adequacy of instrumental variables, serial correlation, functional form misspecification, non-normality and heteroscedasticity in the residuals, respectively.

t-statistics are in parenthesis. *** Significant at 1%, ** significant at 5%, *significant at 10%.

Source: Author's calculations.

Table 2. Guatemala: Effect of Schooling on Growth by Level of Education, 1951-2002

$$\Delta \log y_t = -\gamma_3(\log y_{t-1} - \alpha \log k_{t-1} - \beta \log H(j)_{t-1} - \delta_{85} DUM85_{t-1} - \delta_{77} DUM77_{t-1} - \delta_{63} DUM63_{t-1} - \delta_{82} DUM82_{t-1}) + \gamma_1 \Delta \log k_t + \gamma_2 \Delta \log k_{t-1} + u_t$$

	j = Primary		j = Secondary		j = Tertiary	
	NLLS	2SNL-IV	NLLS	2SNL-IV	NLLS	2SNL-IV
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-0.212 (6.24)***	-0.255 (3.26)***	0.060 (1.43)	0.072 (1.40)	0.140 (2.30)**	0.150 (3.03)***
γ_3	-0.242 (5.51)***	-0.299 (3.93)***	-0.231 (5.94)***	-0.247 (5.21)***	-0.223 (5.14)***	-0.306 (5.37)***
$\log k_{t-1}$ a/	0.445 (5.34)***	0.566 (2.95)***	0.381 (4.49)***	0.305 (2.32)**	0.514 (5.50)***	0.421 (3.94)***
$\log H_{jt-1}$	0.426 (5.58)***	0.437 (4.06)***	0.198 (5.78)***	0.181 (4.64)***	0.096 (4.79)***	0.090 (5.89)***
DUM85	0.718E-2 (3.76)***	0.641E-2 (2.47)***	0.421E-2 (2.05)***	0. 497E-2 (2.15)**	0. 163E-2 (0.62)	0. 242E-2 (1.16)
DUM77	-0.121 (4.32)***	-0.143 (2.78)***	-0.170 (4.96)***	-0.143 (3.34)***	-0.143 (4.07)***	-0.117 (3.83)***
DUM63	0.238 (3.65)***	0.202 (2.72)***	0.239 (3.70)***	0.219 (3.26)***	0.243 (3.30)***	0.173 (3.27)***
DUM82	-0.285 (3.04)***	-0.118 (0.66)	-0.316 (3.38)***	-0.356 (2.37)**	-0.304 (2.86)***	-0.253 (2.13)**
$\Delta \log k_t$	0.871 (28.82)***	1.048 (4.40)***	0.864 (29.54)***	0.778 (6.50)***	0.869 (27.92)***	0.761 (6.44)***
$\Delta \log k_{t-1}$	0.113 (2.94)***	0.103 (0.66)	0.120 (3.23)***	0.185 (1.94)**	0.081 (2.13)**	0.158 (1.67)*
$\overline{R}^2$	0.962	0.924	0.965	0.958	0.960	0.959
Sargan IV test (χ^2)	---	4.005 [0.14]	---	7.772 [0.10]	---	7.059 [0.13]
S.E. of regression	0.012	0.017	0.012	0.013	0.012	0.013
χ^2_{sc}	0.206 [0.65]	0.004 [0.95]	0.273 [0.60]	0.950 [0.33]	0.017 [0.90]	0.857 [0.35]
χ^2_{ff}	0.550 [0.46]	0.795 [0.37]	0.265 [0.61]	0.068 [0.79]	0.626 [0.43]	0.665 [0.42]
χ^2_{N}	2.002 [0.37]	0.730 [0.69]	0.915 [0.63]	1.924 [0.38]	0.225 [0.89]	0.035 [0.98]
χ^2_{HS}	1.491 [0.22]	0.004 [0.95]	0.467 [0.50]	2.123 [0.15]	0.390 [0.53]	0.613 [0.43]
N	51	50	51	50	51	50

a/ Lags of the independent variables are used as instruments. b/ Asymptotic critical values of the t-ratio are from Banerjee et al. (1998). c/ A Breusch-Godfrey test finds no evidence for the presence of first, second and third order correlation in the residuals.

t-statistics in parenthesis. ** Significant at 1%, * significant at 5%.

Source: Author's calculations.

Table 3 . Guatemala: Production Function with Mincerian Human Capital Specification, 1951-2002

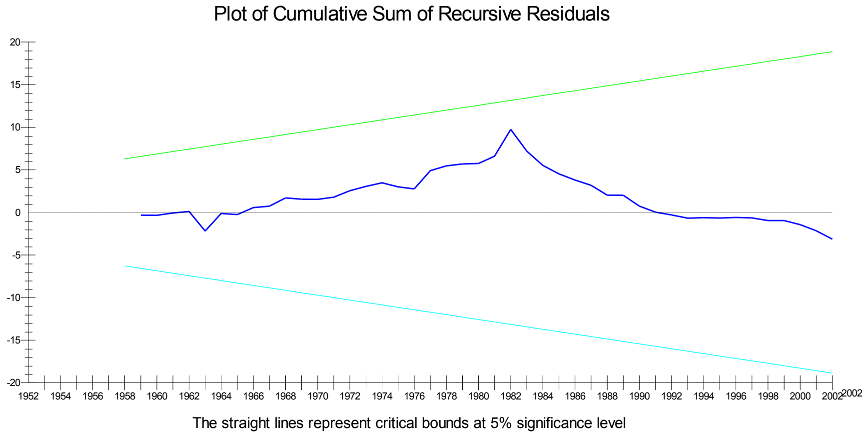
$\Delta \log y_t = -\gamma_3(\log y_{t-1} - \alpha \log k_{t-1} - (1-\alpha)e^{\theta H_{t-1}} - \delta_{77} D77_{t-1} - \delta_{63} D63_{t-1} - \delta_{82} D82_{t-1}) + \gamma_1 \Delta \log k_t + \gamma_2 \Delta \log k_{t-1} + u_t$		
	NLLS	2SNL-IV [a/]
Explanatory variables	(1)	(2)
Constant	-0.947 (8.81)***	-0.961 (10.36)***
$\log y_{t-1}$ [b/]	-0.182 (4.95)***	-0.227 (5.03)***
$\log k_{t-1}$	0.308 (2.62)**	0.281 (2.73)***
$e^{\theta \times H_{t-1}}$	0.135 (8.05)***	0.128 (9.08)***
$DUM77$	-0.158 (3.70)***	-0.142 (4.04)***
$DUM63$	0.316 (3.42)***	0.254 (3.41)***
$DUM82$	-0.386 (2.93)***	-0.325 (3.16)***
$\Delta \log k_t$	0.864 (27.77)***	0.825 (15.42)***
$\Delta \log k_{t-1}$	0.100 (2.59)**	0.133 (3.00)***
$\overline{R}^2$	0.960	0.960
Sargan IV test (χ^2)	---	14.024 [0.05]
S.E. of regression	0.012	0.012
χ^2_{sc}	0.180 [0.67]	0.029 [0.87]
χ^2_{ff}	0.728 [0.39]	1.619 [0.20]
χ^2_{N}	1.150 [0.56]	1.150 [0.56]
χ^2_{HS}	1.160 [0.28]	1.274 [0.26]
N	51	50

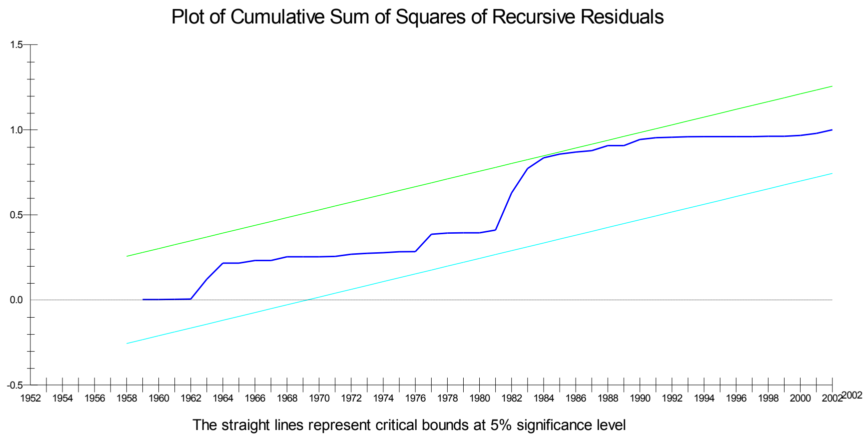
a/ Lags of the independent variables are used as instruments. b/ Asymptotic critical values of the t-ratio are from Banerjee et al. (1998). c/ A Breusch-Godfrey test finds no evidence for the presence of first, second and third order correlation in the residuals.

t-statistics in parenthesis. ** Significant at 1%, * significant at 5%.

Source: Author's calculations.

Figure 2. Parameter Stability





Note: Production Function with average years of schooling specification, based on the NLLQ estimate, presented in Table 4, column 1.

Table 6. Guatemala: Growth Effects of Alternative Measures of Human Capital, 1951-2002

$$\Delta \log y_t = -\gamma_3 (\log y_{t-1} - \alpha \log k_{t-1} - (1-\alpha) e^{\theta H_{t-1}} + \beta_i Z_i - \delta_{77} D77_{t-1} - \delta_{63} D63_{t-1} - \delta_{82} D82_{t-1}) + \gamma_1 \Delta \log k_t + \gamma_2 \Delta \log k_{t-1} + u_t$$

	(1) K-Quality	(2) H-B	(3) H-CO	(4) H-B MEX	(5) H-CO MEX	(6) Basic	(7) Mincer
Constant	-0.341 (5.58)***	-0.313 (6.66)***	-0.244 (8.13)***	-0.864 (5.58)***	-0.737 (9.31)***	-0.346 (6.53)***	-0.807 (16.89)***
$\log y_{t-1}$	-0.186 (3.30)***	-0.277 (5.54)***	-0.259 (5.53)***	-0.270 (5.00)***	-0.268 (5.41)***	-0.294 (4.90)***	-0.250 (1241)***
$\log k_{t-1}$	0.409 (2.51)**	0.433 (3.22)***	0.404 (4.34)***	0.414 (2.52)**	0.446 (5.00)***	0.486 (4.72)***	0.453 (11.21)***
$\log H_{t-1}$	0.413 (5.79)***	0.491 (7.50)***	0.293 (5.41)***	---	---	0.408 (4.77)***	---
$e^{\theta \times H_{t-1}}$	---	---	---	0.192 (6.43)***	0.101 (8.19)***	---	0.155 (18.18)***
MEX_{t-1}	---	---	---	---	---	-0.211E^{-5} (2.06)**	-0.886E^{-6} (1.42)
$DUM77$	-0.163 (3.29)***	-0.263 (5.45)***	-0.162 (5.26)***	-0.211 (4.72)***	-0.119 (4.86)***	-0.134 (2.85)***	-0.147 (5.18)***
$DUM63$	0.302 (2.60)**	0.205 (3.42)***	0.207 (3.29)***	0.193 (0.19)***	0.171 (2.88)***	0.189 (2.65)**	0.199 (9.17)***
$DUM82$	-0.438 (2.61)**	-0.219 (2.05)**	-0.253 (2.87)***	-0.194 (1.56)	-0.268 (2.99)***	-0.245 (3.13)***	-0.303 (6.42)***
$\Delta \log k_t$	0.963 (17.27)***	0.913 (6.61)***	0.858 (19.63)***	0.908 (6.06)***	0.860 (19.08)***	0.831 (20.91)***	0.861 (20.87)***
$\Delta \log k_{t-1}$	0.143 (2.99)***	0.072 (0.81)	0.120 (2.32)**	0.053 (0.53)	0.137 (2.58)**	0.128 (2.61)**	0.131 (4.34)***
$\overline{R}^2$	0.959	0.958	0.976	0.960	0.974	0.975	0.975
Sargan IV test (χ^2)	12.54 [0.13]	0.456 [0.80]	1.039 [0.60]	1.120 [0.57]	3.648 [0.16]	8.199 [0.32]	8.023 [0.33]
S.E.	0.013	0.013	0.010	0.013	0.011	0.010	0.010
χ^2_{sc}	0.015 [0.90]	0.408 [0.52]	0.587 [0.44]	0.002 [0.97]	0.007 [0.93]	0.023 [0.88]	0.115 [0.74]
χ^2_{ff}	0.183 [0.67]	1.635 [0.20]	1.158 [0.22]	0.763 [0.38]	0.085 [0.77]	1.580 [0.21]	0.065 [0.80]
χ^2_N	3.759 [0.15]	4.953 [0.08]	0.239 [0.89]	4.657 [0.10]	0.814 [0.67]	1.111 [0.57]	0.245 [0.89]
χ^2_{HS}	1.171 [0.28]	0.815 [0.37]	0.206 [0.65]	0.995 [0.32]	0.200 [0.65]	0.333 [0.56]	1.177 [0.28]

Z is a vector of hypothesised determinants of growth.

a/ Lags of the independent variables are used as instruments. b/ Asymptotic critical values of the t-ratio are from Banerjee et al. (1998). c/ A Breusch-Godfrey test finds no evidence for the presence of first, second and third order correlation in the residuals.

t-statistics in parenthesis. ** Significant at 1%, * significant at 5%.

Source: Author's calculations.