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TIME SERIES EVIDENCE ON EDUCATION AND GROWTH: THE CASE OF GUATEMALA, 1951-2002**

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Abstract

This article investigates the impact of education on economic growth in Guatemala for the 1951-2002 period. An error-correction model shows that a better-educated labor force has a positive and significant impact on economic growth. A growth-accounting framework demonstrates that human capital explains about 50 percent of output growth. The findings are robust to changes to the conditioning set of variable, while controlling for data issues and endogeneity. The results also compare favorably with the microeconomic evidence.

Keywords: *Education, Economic Growth, Econometrics, Guatemala.*

JEL Classification: *I20, C22, C51, O54.*

I. Introduction

This study examines the contribution of human capital to economic growth in Guatemala over the past 50 years. The interest is twofold. First, the empirical evidence on growth and human capital, as measured by average years of

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schooling, comes almost entirely from cross-country analysis.[1] While there is strong theoretical support for a key role of human capital in growth, authors such as Sala-i-Martin (2002), Easterly (2001) and in particular Pritchett (2001) argue that the empirical relationship between education and growth is often weak. More specifically, Temple (2001) points out that fragile correlations in cross-country data may be due to large measurement errors and influential exceptions. The cross-section focus may also be inadequate if returns to education or the quality of education differ substantially across countries. Consequently, case studies may be more illuminating since they overcome the heterogeneity problem and take into account the unique historical information for each country. Indeed, the original motivation of studying economic growth focuses on the time-series dynamics of macroeconomic variables.

Second, for the case of Guatemala there are very few studies that thoroughly analyze past growth patterns, and there are no studies that empirically appraise the direct impact of education on growth. This study, probably for the first time, constructs a reliable data set that accounts for the determinants of long-run growth in Guatemala. In terms of data availability, the country constitutes a most precarious case. Despite these caveats, however, satisfactory and coherent time series data were obtained. The empirical analysis is based on an error-correction methodology, deals with endogeneity, and explores several data construction and robustness issues. All this may be relevant for future case studies as well.

The main finding suggests that a better-educated labor force has a significant positive impact on long-run growth. Interestingly, the results also suggest that the effect of education in both micro and macro regressions is of similar magnitude. Overall, the econometric results have been found robust, even after controlling for endogeneity and alternative data. The reminder of this article is organized into seven sections. Section II briefly assesses patterns of growth and some of the reasons that led to a low endowment of human capital in Guatemala. Section III discusses how to measure the contribution of human capital to growth over time. Section IV introduces the empirical methodology and presents the main results. Section V tests the robustness of the results. Based on these findings, Section VI accounts for the sources of growth. Section VII concludes.

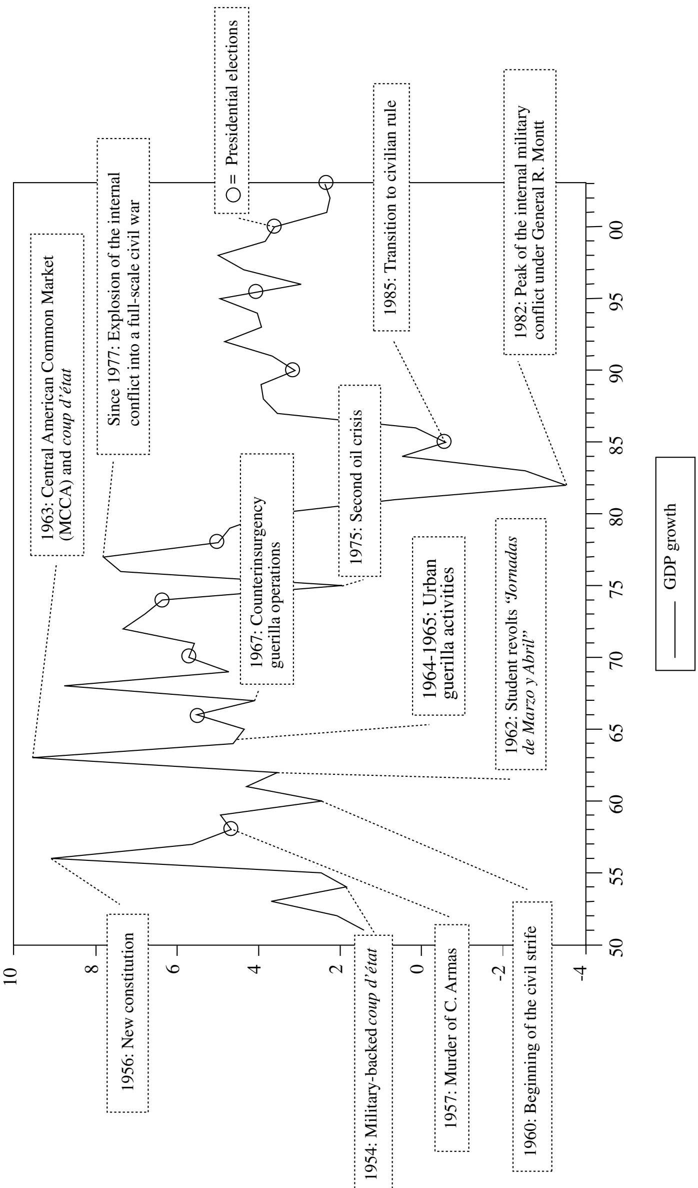
II. Patterns of Growth in Guatemala

To understand Guatemala's growth patterns, and hence the role of education, its turbulent political and social history must be taken into account. Average annual growth rates were about 3.9 percent between 1951 and 2002. According to Bailén (2001) this is in line with the neighbor countries.[2] Due to rapid population growth, however, *per capita* growth in Guatemala has averaged only about 1.3 percent per year. A continuation of this growth rate implies that the average Guatemalan would need approximately 53 years to double his real income. The country'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 taken from Luján (2000).[3]

During 1951-1975, Guatemala maintained reasonable growth rates. Ever since the 1954 coup, military governments were repeatedly in power, sometimes through fraudulent elections, sometimes by *coup d'états*. In terms of its growth

FIGURE 1

GUATEMALA: ECONOMIC GROWTH, SOCIAL CONFLICT AND POLITICS, 1951-2003
(Growth rates in percent)



Source: Author's elaboration based on data from Banco de Guatemala, data for 2002-2003 is preliminary. Historical events are taken from Luján (2000).

performance, this era is sometimes referred to as the 'golden period' but the denomination is very misleading. This is because the structural imbalances of the economy remained unchanged and ultimately gave rise to the explosion of civil strife. Annual growth was highly volatile and associated with the dependence on agricultural export growth as well as political events.

A second period, 1975-1985, can be characterized by external shocks and the civil war. It starts shortly after the international oil crisis. In 1976 a major earthquake affected Guatemala. After 1977, social tension culminated in a full-scale civil war that reached genocidal proportions in the early 1980s. Consequently, growth declined dramatically. Apart from causing immense human sorrow, these events destroyed human life and physical capital. They also imposed high costs for long-run growth.

Finally, a third episode of growth begins approximately in 1985 when democracy was restored. Although growth rates recovered, they have ever since followed a more or less stagnant pattern. Guatemala's cornerstone in economic and social development was the signing of the Agreement of a 'Firm and Lasting Peace' in December 1996, the formal end to the civil war. Since the signing of the UN-sponsored Peace Accords, Guatemala has made progress by increasing investments in infrastructure and human capital. It has also made some efforts to improve public financial management, and in the area of tax revenues.

However, UNDP (2003a) finds that the implementation of the Peace Accords has been uneven. Guatemala traditionally scores poorly on most governance indicators, particularly those for corruption, the rule of law and the justice system. Historically, growth was not particularly pro-poor, i.e. favoring the rural or agricultural economy where the poor live. Growth in Guatemala's was accompanied by the exclusion of large parts of the society from wealth, and, as a consequence, accompanied by underlying social conflict. Poverty rates and inequality indicators are among the highest in the Latin American region. According to the World Bank (2003a) about 56 percent of Guatemala's population live in poverty. The culmination of these factors ultimately seems to damage the climate for growth and investment.[4]

Somewhat paradoxical, over the past decades, Guatemala has experienced relative macroeconomic stability. Guatemala has a rather low level of external indebtedness, inflation has been held back, and after a process of structural reforms the economy is now fairly open and with low levels of protection. Thus, macroeconomic mismanagement may presumably not be regarded as the main factor to understand Guatemala's modest performance in terms of per capita growth. Rather, other issues seem to undermine Guatemala's long-run growth patterns. In addition to the factors already mentioned, one is low human capital endowment.

The current human capital base is essentially a product of these eminently anti-distributional policies. The World Bank (2003a) 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 and a discriminatory education system provided little incentives to accumulate human capital.

TABLE 1

GUATEMALA, CENTRAL AND LATIN AMERICA: COMPARISON OF HUMAN CAPITAL INDICATORS, 1998-2002

Indicator	Guatemala	Nicaragua	Honduras	El Salvador	Costa Rica	Mexico	Latin America
Public spending on education (in percent of GDP) (average 1998-2000)[a/ b/]	1.7	5.0	4.0	2.3	5.7	4.4	N.D.
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 enrollment (in percent) (2000-2001)[c/]	26	36	N.D.	39	49	60	64
Adult illiteracy (in percent of total population) (2002) [c/]	30.1	32.9	23.8	20.3	4.2	8.3	10.5

Source: a/ UNDP (2003b). b/ Notice that Guatemala's public spending in education has increased recently. UNDP (2003a) reports a figure of 2.6 percent in 2002. b/ Cohen and Soto (2001). c/ World Bank (2003b). N.D. = no data available.

Table 1 shows that the country still performs poorly for indicators of education, despite some improvements over time (Anderson, 2001). 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.

III. Measuring the Contribution of Education to Growth

The existing literature contains a number of distinct conceptual 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 and the new growth theories. Distinguishing between the role of education as a factor of production, and as a factor that facilitates technology absorption and the production of knowledge is significant. Any policy measure which raises the level of human capital may only have a one-and-for-all effect in the first framework, but will increase the growth rate of the economy forever in the second one. In such cases, the estimated increase in productivity is not simply a phenomenon in the transitional period since an increase in the flow of education leads to a gradual increase in human capital stock. Implicit is the claim that by increasing the level of education the rate of economic growth will increase over time. Empirically, however, there is no consensus over which is the appropriate approach.

One way to estimate the impact of education on growth is to adapt the Solow (1956) model. The augmented version extends the basic framework to allow human capital as an extra input to enter the production function. In particular Mankiw *et al*. (1992) show that traditional growth theory can accommodate human capital and 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 insufficient to achieve long-run *growth*. Long-run growth depends rather on growth in technological progress. Human capital accumulation may therefore have only a short-term impact on the rate of growth.

However, 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 balanced growth process- 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. Up to now, for the reasons clarified below, this approach has remained the workhorse of applied empirical research. The model is fairly flexible and allows for alternative specifications that can be adjusted to best match the available data.

Expanding these ideas, new growth theories emphasize the endogenous determination of technological progress, which is determined within the model. Thus, long-run growth can be affected by government policies instead of being driven by exogenous technological change. With respect to human capital, the endogenous growth approach argues that there should be an additional effect over and above the static effect on the level of output. Models that explain long-run growth by focusing on technological progress and research and development, such as Romer (1990a) and Grossman and Helpman (1991), argue that domestic technological progress results from the search for innovations. The discovery of an innovation, undertaken by profit-maximizing individuals, raises productivity and is ultimately the source of long-run growth. This kind of model attributes growth to the existing stock of human capital. A second category is the model of Lucas (1988). It broadens the concept of capital and suggests that human capital accumulation may be an engine of growth itself, due to spillover effects that negate diminishing returns in production.

In particular with respect to developing countries, one way of characterizing the role of human capital is the consideration of technology transfer from innovating countries. Already Nelson and Phelps (1966) suggested that education facilitates the adoption and implementation of new technologies, which are continuously invented. For example, countries with lagging technological capacity may be most able to catch-up if they have a large stock of human capital. In this case, the level of human capital enforces growth by facilitating improvements in productivity. Also Lucas (1990) conjectures that physical capital does not flow from rich to poor countries because of a relatively low stock of complementary human capital.

In a rather influential study, Benhabib and Spiegel (1994) propose an empirical growth model in which human capital externalities can be considered in subsequent advances in education and in new physical capital via technology import. Their results indeed suggest that human capital impacts growth through two mechanisms. On the one side, human capital seems to influence the rate of domestically produced innovation, as proposed in the endogenous growth model of Romer (1990a). On the other side, in the spirit of Nelson and Phelps (1966), they claim that the human capital stock affects the speed of adoption of technology from abroad. More recently, in a generalized version of their model of technology diffusion -that allows for a nonlinear specification of total factor productivity growth- Benhabib and Spiegel (2003) find that a minimum initial human capital level is necessary to exhibit catch-up in productivity relative to the leader nation.

However, Pritchett (2001) argues convincingly that the finding of only a level effect on growth is rather puzzling. First, in the framework of endogenous growth, spillover effects of knowledge should be *in addition* to rather *instead* of the production effects of human capital. In other words, finding only spillover effects is inconsistent with the micro evidence on the returns to education. Second, especially relevant for the present study, Jones (1995) criticism of endogenous growth models applies here. Testing endogenous growth models in the context of time series implies establishing a relationship between a variable that is usually stationary -without drift- such as income growth, and a variable which is usually non-stationary, such as years of schooling. In other words, his results fundamentally call into question the implicit prediction of many endogenous growth models suggesting output growth should exhibit large permanent increases. Time series data over a very long time period for the United States and other OECD countries reveal that the growth rates of GDP per capita in these countries exhibit little persistent changes, and can be characterized by a more or less constant mean. This observation imposes a testable prediction. According to endogenous growth models permanent changes in certain policy variables, such as schooling, or the number of scientists and engineers engaged in research and development, should have permanent effects on the rate of economic growth. Empirically, however, neither in the United States nor in other OECD countries does economic growth seem to exhibit such an effect. Incidentally, albeit for different reasons than in the OECD countries, these stationarity properties seem to be equally true for schooling and income growth in the Guatemalan data, as demonstrated in the Augmented Dickey-Fuller (ADF) tests in Table 2.

Another problem emerges from observational equivalence. This means that, despite a number of different ways of hypothesizing how human capital can affect growth, empirical analysis can yield similar predictions regarding the relationship between some human capital variables and some variables of income growth. In other words, apart from data uncertainty, the empirical research seeking to test these alternatives has been hampered by the use of relatively similar econometric specifications. Insofar, macro regressions do not readily allow testing one theory against another. Rather they tend to emphasize an expanded set of variables as suggested by the literature. Consequently, Romer (1990b) argues that the role of an endogenous growth framework is not to generate testable predictions, but rather to guide the process of data analysis.

To summarize, attempts to measure empirically the impact of education on growth can be divided into two broad categories. The augmented Solow model originates the first class, while the second group is inspired by an endogenous growth approach. However, this is rather a conceptual framework for thinking about growth, which can be useful in the analysis of data, but does not generate a set of easily testable equations nor sharp quantitative predictions. In the light of observational equivalence and given the problems associated with testing endogenous growth models in a time series context, the following analysis will be based on a production function augmented for human capital. Nevertheless, some attention will be given to variables that proxy technological innovation, and their joint impact on education.

IV. Empirical Evidence for Guatemala

The following empirical strategy 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 and can be represented in a Cobb-Douglas production function with constant returns to scale:

$$Y_t = A_t \cdot K_t^{\alpha} \cdot H_t^{\beta} \cdot L_t^{(1-\alpha-\beta)} \tag{1}$$

where Y represents output and A is the level of technology or total factor productivity.[5] K, H and L are physical capital, human capital and labor. Multicollinearity between capital and labor is avoided by standardizing output and the capital stock by labor units, which also impose the restriction that the scale elasticity of the production factors is equal to unity. Converted into a logarithmic expression, the production function can be estimated in its structural form:

$$\log y_t = \log A_t + \alpha \cdot \log k_t + \beta \cdot \log h_t + u_t \tag{2}$$

where the lower case variables $y = Y/L$ and $k = K/L$ are output and physical capital in intensive terms, and $h = H/L$ stands for average human capital. At first glance, the formula already appears suitable for estimation. However, some problems arise since macroeconomic time series usually contain unit roots. The regression of one non-stationary series on another is likely to yield spurious results. As reported in Table 2, the data for Guatemala is no exception. The estimation bias can be removed by transforming the time series to stationarity, for example, 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.

TABLE 2

GUATEMALA: AUGMENTED DICKEY-FULLER TEST FOR UNIT ROOTS

Variables	ADF test statistic	
	Levels	First differences
log y	– 2.24	– 4.87**
log k	– 1.85	– 4.36**
log h (author's estimate)	– 0.23	– 2.97*
log h (Barro and Lee)	– 0.72	– 4.76**
log h (Cohen and Soto)	– 1.49	– 4.54**
log trade volume/GDP	– 1.91	– 4.21**
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 lag length was determined using the Schwartz criterion. The MacKinnon critical values are – 3.59 (– 2.93) at the 1 (5) percent level.

Source: Author's calculations.

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 cross-country studies. Examples of this are Nehru and Dareshwar (1994), Morales (1998), and Bassanini and Scarpetta (2001). The error-correction model can be estimated in different ways. Banerjee *et al.* (1993) 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. Following Hendry's (1995) general-to-specific approach, where the least significant variables are successively eliminated, the error-correction model of the human capital augmented production function for Guatemala can be specified as follows:

$$\Delta \log y_t = \gamma_1 \cdot \Delta \log k_t + \gamma_2 \cdot \Delta \log k_{t-1} - \gamma_3 \cdot (\log y_{t-1} - \alpha \cdot \log k_{t-1} - \beta \cdot \log h_{t-1} - \log A_{t-1}) + u_t \quad (3)$$

For Guatemala, in line with much empirical cross-country research, the short-run effects of schooling on growth have been found insignificant and are as such excluded from the regressions. This suggests that only the *level* of human capital has a long-run effect on economic *growth*. As it stands, the equation can be estimated by ordinary least squares (OLS) or instrumental variables (IV) techniques,[6] but the coefficients cannot be formed without knowledge of *a* and *b*. However, one can estimate the re-parameterized form:

$$\Delta \log y_t = c + \gamma_1 \cdot \Delta \log k_t + \gamma_2 \cdot \Delta \log k_{t-1} + \gamma_3 \cdot \log y_{t-1} + \gamma_4 \cdot \log k_{t-1} + \gamma_5 \cdot \log h_{t-1} + \sum_j \delta_j \cdot dummy_{j,t} + u_t \quad (4)$$

Estimates of the parameter γ_3 can now be used to calculate the required elasticities α and β. The loading coefficient, γ_3, contains additional information because it can be interpreted as a measure of the speed of adjustment in which the system moves towards its equilibrium on the average. In addition, Banerjee *et al.* (1998) argue that in a single equation framework a significant coefficient serves as a test for cointegration. Notice that the technology parameter, *A*, is allowed to change overtime as a function of different variables, *Z*:

$$\log A_t = f(Z_t) \quad (5)$$

where in its simplest formulation the technology level is proxied by a constant term, *c*, and a series of dummy variables. In Section V, proxy variables with respect to growth of trade openness, imported capital goods and governance will be included in the equation.

The majority of the following regressions include three dummies. First, a 1963 impulse dummy captures a positive one-off effect stemming from expectations regarding the joining of the Central American Common Market (MCCA). Second, a 1982 impulse dummy takes into account a negative one-off effect stemming from the peak of internal war. Third, a 1977 step dummy which models a structural change in the long-run relationship of the variables. A Chow breakpoint test does not reject the null hypothesis of no structural change during that year (p = 0.000). In fact, the 1977 dummy is always negative, very significant, and most likely corrects for the deviations resulting from the civil strife. It is important to emphasize that the following results are not sensitive to the impulse dummy variables. However, it is important to model the structural break.

TABLE 3

PRODUCTION FUNCTION FOR GUATEMALA: AVERAGE YEARS OF SCHOOLING SPECIFICATION, 1951-2002

Explanatory variables	Dependent variable: Percent change of GDP/worker	
	OLS	IV[a/]
	(1)	(2)
Constant	– 0.077** (– 4.74)	– 0.077** (– 3.76)
Percent change of capital/worker	0.871** (30.2)	0.774** (5.74)
Percent change of capital/worker [–1]	0.120** (3.28)	0.169* (2.58)
log GDP/worker [–1] [b/]	– 0.241** (– 5.87)	– 0.269** (– 5.28)
log capital/worker [–1]	0.107** (3.76)	0.099* (2.29)
log average years of schooling [–1]	0.084** (5.00)	0.090** (4.54)
Step dummy 1977	– 0.041** (– 4.47)	– 0.039** (–3.38)
Impulse dummy 1963	0.057** (4.69)	0.056** (4.15)
Impulse dummy 1982	– 0.077** (– 4.88)	– 0.087** (– 4.09)
Long-run elasticity of capital	0.444	0.366
Long-run elasticity of schooling	0.351	0.334
Adjusted R^2	0.964	0.956
F-statistic	170.5	40.67
Durbin Watson [c/]	2.003	2.112
S.E. of regression	0.012	0.013
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.

Table 3 shows the results for the average years of schooling specification (the data sources for the estimate are described in the Appendix). The adjusted R^2 of the error-correction model is rather high and indicates a good data fit. Test statistics do not indicate any serial correlation or misspecification at conventional levels. The residuals have been found to be normally distributed and to follow stationary patterns. If not mentioned otherwise, these properties apply equally to subsequent regressions. The loading 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 the level of output consistent with long-run growth (with differences to be less than 10 percent). In the subsequent regressions, however, the magnitude of the coefficient -but not its significance- was found to be fragile with respect to the econometric specification. The asymptotic critical values of the t-ratio for the coefficient are taken from Banerjee *et al*. (1998). The significance level suggests a cointegrating relationship of the variables.[7]

The most striking result is that human capital, as measured by average years of schooling, has a highly significant, positive and strong impact on long-run growth. Column 1 reports the implicit long-run coefficients estimated by OLS.[8] Since education levels are likely to respond to growing employment opportunities and increased income, column 2 shows the regression results when IV techniques are applied. In this case, lags of the explanatory variables are used as instruments. Compared to the OLS estimate, the quality of the results does not vary much with the IV estimation. The estimating parameters are in both cases significantly different from zero and the regressions, as test statistics indicate, show a satisfactory performance. However, the implicit elasticity of the human capital coefficient is slightly reduced. The capital coefficient is sharply reduced. The endogeneity problem, thus, does not distort the estimate but has an impact on the magnitude of the coefficients. In the IV specification, the estimated long-run effect of a 1 percent increase of average schooling on GDP per unit of labor is 0.33 percent. As such, it is roughly consistent with a priori expectations on the magnitude of the factor share of human capital.[9] The results in terms of the human capital augmented Cobb-Douglas production function are approximately as follows:

$$Y_t = A_t \cdot K_t^{1/3} \cdot H_t^{1/3} \cdot L_t^{1/3} \tag{6}$$

where the reported parameter values will serve as the base in a later growth accounting exercise. Notice that despite different methodologies the capital elasticity is broadly in line with empirical analyses, which estimate a Cobb-Douglas production function for Guatemala.[10]

There are two additional findings of interest. First, even in the IV estimate, physical capital accumulation has a rather high impact on short-run growth. This suggests that measures to stimulate investment, for example by improving the investment climate, are likely to have an immediate impact on short-run growth. Second, the interception is significantly negative. Since the constant is expected to proxy for technology, a negative parameter in the sense of 'technological regress' is hard to understand. However, a loose interpretation for this finding would be that during the past 50 years, on average, the economy was not particularly efficient. One reason for that might be the conflicting political and social environment of Guatemala.

Another 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 (2001) estimate the following production function:

$$Y_t = A_t \cdot K_t^{\alpha} \cdot HM_t^{(1-\alpha)} \tag{7}$$

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:

$$HM_t = e^{\psi \cdot h_t} \cdot L_t \quad \Leftrightarrow \quad hm_t = e^{\psi \cdot h_t} \tag{8}$$

where hm_t is the human capital per worker, h_t is average years of schooling and ψ corresponds to the returns to education. 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 in a manner that is consistent with the standard semi-logarithmic formulation for estimating returns to schooling at the micro level. As such, according to Wößmann (2003), it provides a way of either confirming or rejecting the importance of education suggested by micro studies.

For the Guatemalan case, the econometric strategy is similar to the previous equations. The production function is first converted into a logarithmic expression:

$$\log y_t = \log A_t + \alpha \cdot \log k_t + (1-\alpha) \cdot \psi \cdot h_t \tag{9}$$

Then, the production function is transformed into an error-correction formulation, which allows the long-run schooling parameter to be identified:

$$\begin{aligned} \Delta \log y_t = {} & \gamma_1 \cdot \Delta \log k_t + \gamma_2 \cdot \Delta \log k_{t-1} \\ & - \gamma_3 \cdot (\log y_{t-1} - \alpha \cdot \log k_{t-1} - (1-\alpha) \cdot \psi \cdot h_{t-1} - \log A_{t-1}) + u_t \end{aligned} \tag{10}$$

Finally, the error-correction model is re-parameterized and includes a series of dummy variables:

TABLE 4

PRODUCTION FUNCTION FOR GUATEMALA: MINCERIAN HUMAN CAPITAL SPECIFICATION, 1951-2002

Explanatory variables	Dependent variable: Percent change of GDP/worker	
	OLS	IV[a/]
	(1)	(2)
Constant	– 0.068** (– 4.28)	– 0.072** (– 3.78)
Percent change of capital/worker	0.865** (28.7)	0.752** (6.05)
Percent change of capital/worker [–1]	0.104** (2.77)	0.163* (2.56)
log GDP/worker [–1] [b/]	– 0.200** (– 5.35)	– 0.240** (– 4.94)
log capital/worker [–1]	0.069* (2.56)	0.058 (1.45)
Average years of schooling [–1]	0.029** (4.56)	0.034** (4.28)
Step dummy 1977	– 0.035** (– 3.97)	– 0.035** (– 3.40)
Impulse dummy 1963	0.058** (4.63)	0.058** (4.11)
Impulse dummy 1982	– 0.070** (– 4.24)	– 0.080** (– 3.85)
Long-run elasticity of capital	0.343	0.240
Effect of 1 additional year of average schooling	0.219	0.184
Adjusted R^2	0.962	0.953
F-statistic	159.2	41.08
Durbin Watson [c/]	1.858	2.133
S.E. of regression	0.012	0.014
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.

$$\Delta \log y_t = c + \gamma_1 \cdot \Delta \log k_t + \gamma_2 \cdot \Delta \log k_{t-1} + \gamma_3 \cdot \log y_{t-1} + \gamma_4 \cdot \log k_{t-1} + \gamma_5 \cdot h_{t-1} + \sum_j \delta_j \cdot dummy_{j,t} + u_t \quad (11)$$

The specification provides an attractive way for comparing macro and micro evidence on the returns to schooling. Table 4 presents the results. Controlling for endogeneity does not distort the empirics. In the IV specification one additional year of schooling increases income per worker by approximately 18.4 percent. This number suggests that the macro return to schooling in Guatemala is rather high, but it compares favorably with 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 equally echoed in Funkhouser (1997). An estimate from Haeussler (1993) based on household survey and Ministry of Education data suggests that, depending on the schooling level and underlying assumptions, the social return to schooling in Guatemala lies in a band between 13-19 percent. Finally, these results also confirm the cross-country evidence from Cohen and Soto (2001). They essentially find that in macro and micro regressions the effect of education on income is of similar magnitude.

V. Robustness Check and Additional Explanatory Variables

The next paragraphs seek to answer one basic question: how much confidence should be placed on the previous results? Evidently, given data uncertainties, the omission of additional explanatory variables and the heavy distortions of the Guatemalan economy caused by the civil war, a key issue is if the previous findings are indeed reliable.

First, an interesting sensitive test concerns the reliability of the human capital stock, estimated for the present study (for details see the Appendix). Column 1 of Table 5 uses interpolated education data from Barro and Lee (2001). Column 2 includes the interpolated time series from Cohen and Soto (2001) into the regressions. In both estimates human capital, as measured by average years of schooling, is robustly correlated with growth. In addition, the parameter estimate yields a long-run elasticity in the range of 0.29-0.39. This magnitude is similar to the benchmark results obtained in the earlier estimate. 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 results.

Second, another important aspect is considered: does the conditioning information set cause the schooling coefficients to change? For example, the production elasticities of human or physical capital could be larger than their factor shares because of presumed externalities. The following paragraphs consider three factors often associated with endogenous growth: trade openness, foreign capital goods and governance.

(1) Trade Openness

Apart from comparative–advantage arguments, it is argued that openness expands potential markets, facilitates the diffusion of technological innovations, improves managerial practices and promotes domestic competition, all of which increase efficiency. Considering the small size of the Guatemalan economy trade openness is of particular interest. For the case of Latin America, Loayza *et al*. (2004) present evidence suggesting a significant relationship between trade openness and growth. Column 3 of Table 5 suggests that the growth rate of trade openness is positively and significantly related to Guatemalan GDP growth. By contrast, the elasticities for physical and human capital do not show much variation.

(2) Foreign Capital Goods

International trade can have an additional impact on growth through the imports of foreign capital goods. 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. Taking into account this potential avenue, the ratio of capital imports to total investment is used as a proxy for the efficiency of capital accumulation. The regression of column 4 in Table 5 indicates that the composition of investment is an important determinant for long-run growth in Guatemala. The implied elasticity suggests that a 1 percent increase in the ratio of capital imports to total investment increases output by about 0.10 percent. Notice that the inclusion of the variable alters the coefficients for capital accumulation but has less impact on the elasticity of average years of schooling.

(3) Governance

Given the strong influence of social conflict, violence and military rule in Guatemala's recent history, it is finally imperative to discuss the role of governance on growth. According to Deger and Sen (1995), the role of military is ambiguous and the direction of the overall effect remains an empirical question. In the context of the present study, it is argued that military spending shows the priority given to other fiscal functions by the government and serves as an indicator of the military's power as a lobby.[11] Guatemalan defence spending reached its height during the peak of the civil war and declined in the advent of the peace process. They eventually began to rise again in 2000. 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,* or PAC) diverted a significant share of the economically active population from

TABLE 5

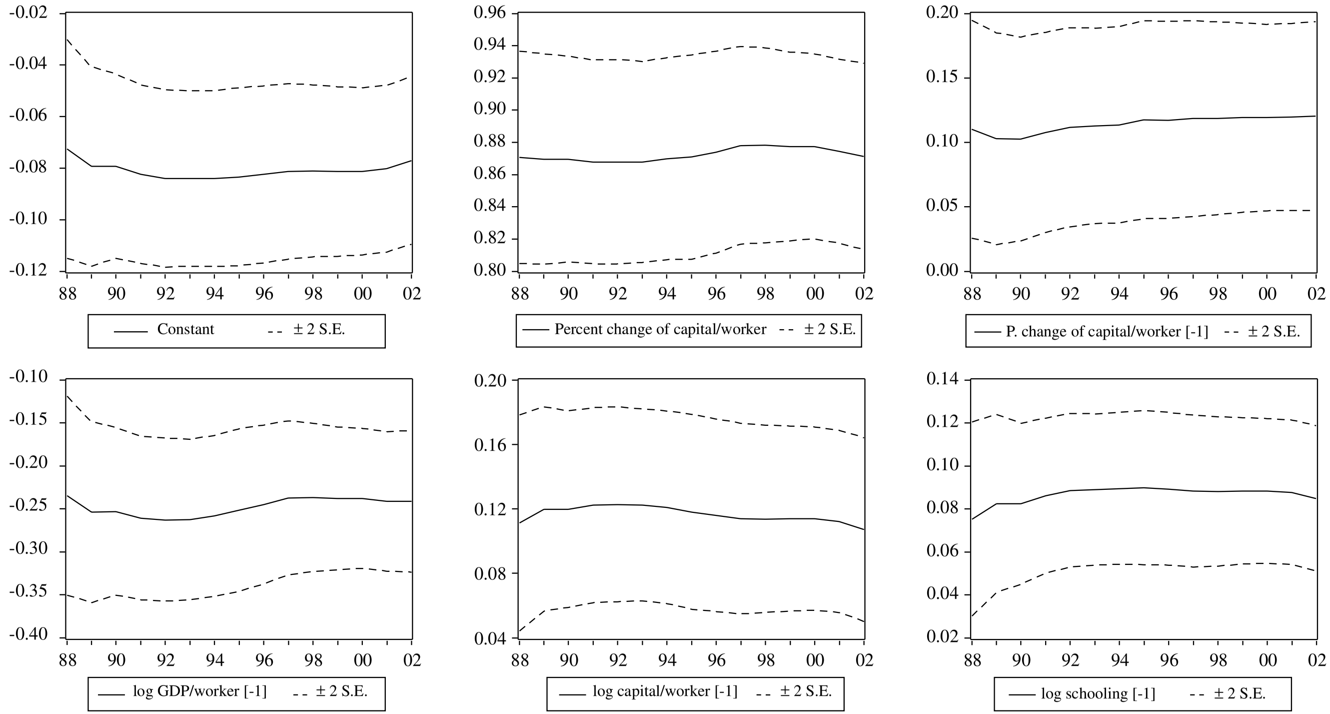
PRODUCTION FUNCTION FOR GUATEMALA: ROBUSTNESS OF RESULTS AND ADDITIONAL EXPLANATORY VARIABLES

	Dependent variable: Percent change of GDP/worker				
	Barro and Lee education data[b/]	Cohen and Soto education data[b/]	Trade openness [b/]	Capital imports/ investment[c/]	Military spending/ GDP
Estimation method and time period	IV 1951-00	IV 1961-02	OLS 1951-02	IV 1951-02	IV 1951-02
Explanatory variables	(1)	(2)	(3)	(4)	(5)
Constant	– 0.073**	– 0.061**	– 0.073**	– 0.070**	– 0.215**
	(– 4.31)	(– 4.43)	(– 5.49)	(– 3.69)	(– 3.85)
Percent change of capital/worker	0.730**	0.847**	0.891**	0.929**	0.846**
	(10.3)	(9.18)	(35.7)	(8.84)	(8.31)
Percent change of capital/worker [–1]	0.160**	0.138**	0.115**	0.118*	0.140**
	(3.28)	(3.16)	(3.56)	(2.20)	(2.81)
log GDP/worker [–1][a/]	– 0.279**	– 0.272**	– 0.227**	– 0.316**	– 0.316**
	(– 5.45)	(– 5.40)	(– 6.76)	(–5.96)	(– 6.38)
log capital/worker [–1]	0.080*	0.108*	0.095**	0.206**	0.159**
	(2.40)	(2.10)	(4.10)	(4.24)	(4.35)
log average years of schooling [–1]	0.133**	0.072**	0.086**	0.092**	0.102**
	(4.86)	(5.53)	(6.00)	(5.19)	(6.20)
Percent change of trade volume/GDP	…	…	0.089**	…	…
			(3.57)		
log imported capital goods/investment [–1]	…	…	…	0.032**	…
				(2.73)	
log military expenditure/GDP [–1]	…	…	…	…	– 0.024*
					(– 2.42)
Long-run elasticity of capital	0.288	0.399	0.420	0.653	0.501
Long-run elasticity of schooling	0.476	0.266	0.378	0.289	0.323
Adjusted R^2	0.955	0.975	0.977	0.965	0.972
F-statistic	59.61	67.88	191.7	45.82	57.49
Durbin Watson	2.441	2.151	2.303	2.308	2.365
S.E. of regression	0.013	0.010	0.009	0.012	0.010
N	49	40	51	50	50

a/ Asymptotic critical values of the t-ratio are from Banerjee *et al*. (1998). b/ Data is interpolated. c/ Includes a time trend starting in 1999 significant at 5%. All regressions include a step dummy for 1977 and impulse dummies for 1963 and 1982 and are significant at 1%.
t-statistics in parenthesis. ** Significant at 1%, * significant at 5%.
Source: Author's calculations.

FIGURE 2

PRODUCTION FUNCTION FOR GUATEMALA: PARAMETER STABILITY



Note: Based on the OLS estimate presented in Table 3, column 1.

productive activities. As such, Guatemalan military expenditures may proxy political corruption, violent conflict or other aspects of bad government. When military expenditures are included into the regression, column 5 of Table 5 reveals a significant negative impact on long-run growth, while the elasticity for human capital does not exhibit significant change.

Finally, given the distortions of the economy by the civil strife and other events, it is imperative to evaluate the stability of the coefficients. Comparing data from different points of time could cause coefficients to show dramatic jumps. In this case, it would be almost impossible to interpret the magnitude and sign of the coefficients. Parameter stability is assessed here using recursive least squares. This allows a year-by-year comparison of the coefficients since ever larger subsets of the time series data are used. Figure 2 visualizes the recursive coefficients of the regressions (Table 3, OLS estimate). Also shown are the standard error bands around the coefficients. The coefficients, in particular the schooling parameter, do not display significant variations when more data is added to the equation. In the light of permanent shocks to the Guatemalan economy, it is reassuring to note that the error-correction specification here is capable of digesting these disruptive events.

VI. Sources of Growth

Growth accounting can be very informative by providing a consistent decomposition of economic growth among its proximate sources. Assuming constant returns to scale and competitive markets, the growth rate of output can be represented as:

$$\frac{\Delta Y_t}{Y_{t-1}} = \frac{\Delta A_t}{A_{t-1}} + \alpha \cdot \frac{\Delta K_t}{K_{t-1}} + \beta \cdot \frac{\Delta L_t}{L_{t-1}} + (1-\alpha-\beta) \cdot \frac{\Delta H_t}{H_{t-1}} \tag{12}$$

where Y, K, L and H represent output, physical capital stock, labor input and human capital stock, respectively. The term A is total factor productivity (TFP) and reflects the relative efficiency of the inputs to produce a given amount of output. The production function elasticities give estimates of factor shares and are used to weigh the relative contribution of the inputs growth rates. The capital and labor shares, α and β, are taken to be equal to $^1/_3$.

Before taking a look at the results, however, it is important to briefly mention some well-known caveats of growth accounting. TFP reflects a whole range of factors since it captures everything that is not accounted for. It is hard to distinguish the effect of technological change from that of improved resource allocation, or from bias resulting from model deficiencies and poor data quality. Thus, TFP estimates may be affected by scale economies and can be sensitive to data perpetuation. In addition, findings in the area of growth accounting require careful interpretation because the technique does not provide information about the interdependencies of the variables. Therefore, growth accounting should be treated with some caution.

With this in mind, Table 6 presents a basic decomposition of GDP growth for Guatemala for 1951-2002. TFP is measured as the residual representing the component of growth not explained by factor accumulation. The results suggest that growth in Guatemala is largely due to the accumulation of inputs. With about 32 percent explaining growth, the role of physical capital accumulation is moderate. Table 6 suggests that human resources are the main engine of growth. In fact, the human capital variable alone explains approximately 50 percent of output growth. The finding of a negative rate of TFP growth of about 7 percent is a somewhat odd result.[12] Rather than 'technological regress' it should be interpreted as an indication of the declining efficiency of the economy, due to the conflicting political and social environment of the country. Notice that TFP growth is consistent with the earlier regression results. In most specifications the constant term was found to be significantly negative.

TABLE 6

GUATEMALA: DECOMPOSITION OF GROWTH, 1951-2002
(In percent)[a/]

Time Period	GDP Growth Rates	Contribution of			
		Capital	Labor	Education	TFP
1951-55	2.3	0.6	– 1.1	– 0.4	3.2
1956-60	5.4	1.7	2.0	3.5	– 1.7
1961-65	5.3	1.1	1.9	3.1	– 0.8
1966-70	5.8	1.7	1.8	2.9	– 0.5
1971-75	5.6	1.6	1.1	2.5	0.5
1976-80	5.7	2.3	2.7	4.0	– 3.4
1981-85	– 1.1	0.6	– 1.0	– 0.2	– 0.6
1986-90	2.9	0.4	1.5	2.2	– 1.3
1991-95	4.3	0.9	0.6	0.8	2.0
1996-00	4.0	1.5	0.4	1.4	0.6
2001-02	2.3	1.3	0.8	2.2	– 2.1
Average	3.9	1.2	1.0	2.0	– 0.3
		32%	25%	50%	– 7%

a/ Discrepancies are due to rounding.
Source: Author's calculations.

TABLE 7

CENTRAL AMERICA AND MEXICO: SOURCES OF GROWTH, 1961-2000
(In percent)

Data Adjusted for Quality of Labor[a/]

Country and time period	GDP growth	Contribution of			Country and time period	GDP growth	Contribution of		
		Capital	Labor	TFP			Capital	Labor	TFP
Guatemala		(0.33)	(0.67)		*El Salvador*		(0.42)	(0.58)	
1961-70	5.5	1.4	5.0	– 0.9	1961-70	5.6	2.8	2.9	0.0
1971-80	5.7	2.0	5.0	– 1.3	1971-80	2.3	3.0	1.8	– 2.6
1981-90	0.9	0.5	1.4	– 1.0	1981-90	– 0.4	0.7	1.9	– 3.0
1991-00	4.1	1.2	1.6	1.3	1991-00	4.6	2.0	2.3	0.3
Nicaragua		(N.D.)	(N.D.)		*Honduras*		(N.D.)	(N.D.)	
1961-70	6.8	2.9	3.0	0.9	1961-70	4.8	2.0	2.3	0.5
1971-80	0.4	1.8	2.5	– 3.9	1971-80	5.4	2.2	2.9	0.3
1981-90	– 1.4	0.8	2.4	– 4.7	1981-90	2.4	1.1	3.9	– 2.6
1991-00	3.3	0.7	3.2	– 0.6	1991-00	3.2	1.8	2.9	– 1.5
Costa Rica		(0.26)	(0.74)		*Mexico*		(0.41)	(0.59)	
1961-70	6.1	1.9	3.3	0.9	1961-70	6.7	3.3	2.7	0.7
1971-80	5.6	2.4	4.5	– 1.3	1971-80	6.7	3.5	3.1	0.2
1981-90	2.4	1.0	2.9	– 1.5	1981-90	1.8	1.7	3.5	– 3.4
1991-00	5.3	1.5	2.4	1.4	1991-00	3.5	1.6	1.9	0.1

a/ Factor shares are in brackets. Discrepancies are due to rounding. N.D. = no data.
Source: Author's calculations for Guatemala. Loayza *et al.* (2004) for Central America and Mexico – data here refers to the growth accounting exercise 2, i.e. adjustments for changes in the quality of labor associated with increases in educational attainment.

How do these estimates compare to other Latin American countries? Table 7 summarizes the results of a study that applies a similar methodology. Loayza *et al*. (2004) focus on the growth performance of 20 Latin American and Caribbean countries. They adjust for changes in the quality of labor associated with increased educational attainment. Consistent with international evidence, Loayza *et al*. find that during the 1990s the recovery in output growth for the 'best' performers in the Latin American region was driven by increases in their rates of TFP growth, and less so by factor accumulation.

However, in most Central American countries TFP growth was only moderate. In some cases it was even negative. While TFP growth in Guatemala appears to be on the high side compared to its Central American neighbors during the 1990s, it is worth recalling that Table 7 does not take into account quality changes of the physical capital stock. If the civil war has contributed to a decay of Guatemala's capital stock, the growth accounting exercise would overstate TFP growth rates. In addition, a one-to-one comparison is hampered by the nature of the different data sources. Overall, Guatemala's growth experience shows similarities with its neighbors, in particular with Costa Rica and El Salvador. During the 1990s these countries have experienced much faster growth than during the 1980s. In particular, quality-adjusted labor–associated with increased educational attainment–was the main source of growth.

VII. Conclusion

Human capital has a highly significant and positive impact on long-run growth in Guatemala. The importance of human capital is substantial. An increase by one percentage point of average years of schooling would raise output by about 0.33 percent. Interestingly, the effect is of similar magnitude to that in micro studies. The study contains additional findings of interest. In particular, a higher degree of trade openness and imported foreign capital goods would enhance technology absorption. The robustness of the error-correction model with respect to data issues, parameter stability and endogeneity concerns are the main reasons for confidence in the overall results. The robustness is even more remarkable in the context of heavy distortions within the Guatemalan economy.

Accounting for the sources of growth supports the importance of human capital in Guatemala. The exercise reveals that the increased skill level has been the main driving force behind productivity growth, and that education explains about 50 percent of output growth during the past five decades. Due to an environment of social and political conflict, however, total factor productivity has been slightly negative over the past decades. The evolution of productivity growth is linked to political events–such as the civil strife and military rule–and suggests a declining efficiency of the economy over time. Ultimately, the findings presented here point towards the importance of an institutional, political and social environment conducive to growth.

Notes

[1] The exception is a study from Jenkins (1995) using time series data from 1971-1992 for the United Kingdom. Still, the limited size of her time series sample makes it difficult to draw conclusions. Also Pissarides (2000) summarizes single case studies for India, Egypt, Tanzania and Chile. Part of an OECD project, these studies were to provide a test of the relation between education and growth in a single country context. However, being plagued with methodological and data problems the studies are rather inconclusive.

[2] For example, growth has been lower than in Costa Rica (4.7 percent) but higher than in Honduras (3.7 percent), El Salvador (3.2 percent) and Nicaragua (2.1 percent).

[3] The correlations do not necessarily imply causality. Moreover, in many Latin American countries growth rates during the decades of the 1950s and 1960s were quite volatile as well.

[4] Larrain (2004) analyzes these issues in more detail.

[5] Further research may focus on a specification less restrictive than a Cobb-Douglas production function to allow a higher degree of precision of the technical coefficients. For example, factor shares are not necessarily constant, and the elasticity of substitution can be less than 1. A potentially interesting avenue is Jones (2004). He presents a production function that exhibits a short-run elasticity of substitution between capital and labor that is less than 1, and a long-run elasticity that equals to 1.

[6] Most of the evidence of the relationship between education and growth is based on statistical correlations. From these correlations it has been generally inferred that higher levels of education cause higher growth. One critique comes from Bils and Klenow (2000) who suggest reverse causation. Therefore, in an econometric framework, schooling should be treated as an endogenous input with respect to income.

[7] Notice equally that the human capital parameters are highly significant and compare favorably with the critical values provided by Pesaran *et al*. (2001). This is reassuring given the small sample size of 50 observations and the consequently low power of the ADF tests, where the stationarity properties of the repressors may not be known with certainty.

[8] The long-run coefficients can be obtained by dividing the estimated parameter through the value of the loading coefficient, for example 0.084/0.241.0.351. Discrepancies are due to rounding.

[9] Mankiw *et al*. (1992) consider the minimum wage as the return to labor with no education. Historically, the minimum wage has been between 30 to 50 percent of average wage income in the United States. On this account, it would follow that the return to education equals about 50 to 70 percent in labor income, which is about 70 percent of total factor income. Obviously, the problem with this kind of calculation is that in countries like Guatemala the minimum wage is less enforced and not applicable. Pritchett (2001) therefore uses an estimation based on the distribution of wages based on survey data, including for Latin America. Either of these calculations suggest that the human capital coefficient should be at least 1/3.

[10] These are generally in the order of 0.3-0.4; naïve estimates based on low-quality data and shorter time horizons can be found in Larrain (2004), Morán and Valle (2002), Segovia and Lardé (2002), and Prera (1999).

[11] Using recently developed econometric methods involving threshold regressions, Reitschuler and Loening (2005) analyze in more detail the impact of defense expenditure on growth in Guatemala.

[12] The TFP estimate was found sufficiently robust. A sensitivity analysis based on alternative assumptions on the factor shares yielded TFP growth estimates ranging from –4 percent (capital share 0.4 and labor share 0.6) to –1 percent (capital share 0.5 and labor share 0.5). The associated changes of the contribution of labor and capital were negligible.

[13] The use of labor force instead of total population data is due to problems regarding the Guatemalan population data for the 1980s. By contrast, the labor force proxy used here is assumed to take into account some of the effects of the civil war, i.e. migration and displacement.

[14] The use of net enrollment ratios is hampered by large data gaps. Also, net enrollment ratios introduce large measurement errors if there are under –or over– aged children starting at each

level of education, see Barro and Lee (2001). In Guatemala students who start late constitute a significant fraction of total enrollment –in particular for primary schooling.

[15] UNDP (2003a) reports a participation rate of 24.5 percent (2002). Based on INE data, as reported by Global Info Group (1999), this compares to 27.6 percent (1995), 29.9 percent (1990) and 28.2 percent (1985).

[16] It should be emphasized that the reliance on IGSS data may understate the drop of the economically active population during the 1980s. This is because the working population in the informal and rural sectors –typically not captured by the social security system– was particularly affected by violence and displacement policies.

[17] The potential error of the estimate of initial capital stock diminishes over time due to depreciation. Based on international data, Nehru and Dhareshwar (1993) offer an estimate of the capital stock for Guatemala that was taken as a benchmark.

[18] UNDP (2002) provides a brief summary of the associated empirical consequences and causes that prevented an actualization of the Guatemalan National Accounts.

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APPENDIX

DATA COMPILATION IN A POST-CONFLICT COUNTRY

Guatemala is definitely deficient in easily accessible data. Thus, to identify the macroeconomic impact of education on economic growth, a primary task is to overcome information constraints. A sizable amount of information, although not easily accessible, can be compiled from disperse or bulky individual files. Even for local experts, this is a challenging task. The lack of a consistent compilation of data to allow a serious analysis of growth patterns has hampered inter-temporal comparisons for the country. Given these constraints, so far, there is very limited empirical research on virtually any macroeconomic topic in Guatemala.

The following paragraphs describe the data needed for the analysis. These are measures for the human and physical capital stock, and the labor force. The time series are mainly from Banco de Guatemala, and, in the case of educational statistics, from the Ministry of Education (MINEDUC) and the United Nations Educational, Scientific and Cultural Organization (UNESCO). Other data sources are listed in Table 8. Table 10 at the end of this Appendix displays the original data.

1. Human Capital Stock

The human capital stock of Guatemala is defined by average years of schooling evident in the labor force.[13] In line with most empirical analyses, this study assumes that years of schooling provides a reasonable approximation of the human capital stock, although it should be briefly stressed that the indicator is incomplete for several reasons.

(1) *Education as proxy variable*

Human capital is multifaceted and includes a complex set of human attributes. As a consequence, the genuine level of human capital is hard to measure in quantitative form. At best, average years of schooling can be regarded as a proxy for the component of the human capital stock obtained in schools.

(2) *Quality changes*

Average years of schooling measurements do not take into account quality changes within the education system. Quality changes may complicate comparison of schooling effects on growth over time as well as making comparisons with

TABLE 8

DATA SOURCES OF TIME SERIES

Variables	Abbreviation	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.
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.
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).
Average schooling (years)	h	Perpetual inventory estimates, see text.
Participation of primary, secondary and tertiary education in labor force	hr_{pri} hr_{sec} hr_{ter}	Perpetual inventory estimates, see text.
Population statistics (15 and 20 year old, 15-64 year old)	*L15* *L20* *L15-64*	CEPAL and CELADE (2000).
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).
Primary and secondary gross enrollment ratios	*PRI* *SEC*	For 1960-1990 UNESCO estimates as reported in World Bank (2003b). 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 (1958, 1961, 1966, various years), Mitchell (1998) and Ministerio de Educación and SEGEPLAN (1980).
Tertiary gross enrollment ratio	*TER*	For 1960-1987 UNESCO estimates as reported in World Bank (2003b). Missing values were either interpolated or completed with information provided in Mitchell (1998), UNESCO (1966) and UNESCO (1958, 1961, 1966, various years). 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).

other countries difficult. Unfortunately, in terms of data availability, it proves impossible to obtain an index of quality changes of education for 1951-2002 in Guatemala. While there is cross-country evidence suggesting that education quality is more fundamental than quantity, for example in Barro (2001), it is believed here that this issue may be of minor relevance for this particular case study. That is, in a country where the quantity and quality of education is still very low, a human capital quality index is probably less important for analytical purposes.

For Guatemala, the scare empirical evidence on the quality of education is evidenced in three studies. Bratsberg and Terrell (2002) carried out an analysis that allows comparing the quality of the Guatemalan education system with that of other countries. They estimate country-specific returns to education among male immigrants in the U.S. labor market. Immigrants are competing in the same market without being affected by their home countries' labor market conditions, and their rates of return are useful pointers to the educational quality of their home country. Given that the workers' characteristics and distance to home countries are controlled for, what accounts for the variations in the returns is the education quality of the home countries. Male immigrants educated in Central America registered the lowest returns among all immigrants, falling even behind the African immigrants in the sample. The returns to education of male immigrants educated in Guatemala were only about 2 percent and well below the average returns to immigrants from Central America. Consequently, it may be inferred that the quality of Guatemala's education system during the past decades was lower than for countries with a similar level of development. Based on country-specific indicators, also CIEN (2002) and the World Bank (1995) claim that the quality of the education system in Guatemala is rather low, and as an important matter of fact for this case study, has not shown much improvement over time.

(3) *Aggregation bias*

Average years of schooling raise human capital by an equal amount regardless of whether a person is enrolled in a primary, secondary or tertiary school. This is an important point because by defining human capital by average years of schooling, one implicitly gives the same weight to any year of schooling acquired by a person. This disregards the findings of the microeconomic literature on wage differentials. For example, Psacharopoulos and Patrinos (2002) suggest that the rates of return to education could be decreasing with the acquisition of additional schooling. However, analyzing the role of primary, secondary and tertiary schooling on growth in Guatemala, Loening (2004a) argues that the aggregation bias is of minor importance. This is because of the predominance of primary schooling in the country.

After making some modifications to account for the statistical circumstances in Guatemala, the following procedure for constructing estimates of the human capital stock is used, based on the attainment census method advocated by Barro and Lee (2001). The use of a perpetual inventory method that employs census and survey information on educational attainment as benchmark figure can be seen as a major advantage over previous methodologies. The benchmarks are taken from various national censuses and surveys, see Table 9. Guatemalan statistics report distributional attainment stratified by age and sex in five cases: no formal education, first cycle of primary, second cycle of primary, first cycle of secondary, second cycle of primary and tertiary education. The data has been summarized into 4 broad categories, that is, no school, some primary, some secondary and some tertiary education.

TABLE 9

GUATEMALA: EDUCATION LEVEL OF LABOR FORCE, 1950-2002
(In percent)[a/]

Year	Source	No school	Some or all primary	Some or all secondary	Some or all tertiary
1950	SEGEPLAN (1978)	72.3	24.9	2.3	0.5
1964	SEGEPLAN (1978)	60.7	33.4	4.7	1.2
1973	SEGEPLAN (1978)	51.7	40.8	6.1	1.4
1981	DGE (1981)	(37.7)	(48.7)	(10.9)	(2.7)
1989	INE (1989)	38.9	47.7	11.4	2.1
1994	INE (1994)	35.4	47.8	14.1	2.7
1998	INE (1998)	(30.8)	(50.3)	15.9	3.1
2000	INE (2000)	28.9	48.6	16.5	6.0
2002	INE (04-05/2002)	26.9	49.3	19.3	4.5
2002	INE (08-09/2002)	24.7	50.8	19.3	5.2
2002	INE (10-11/2002)	25.0	48.7	21.0	5.3

a/ Brackets indicate uncertain figures. Discrepancies are due to rounding.
Source: Compiled from census and survey data, INE (2000) and (2002) figures are from UNDP Guatemala.

The procedure starts to construct current flows of adult population, which are added to the initial benchmark stocks of the labor force (taken for 1950 from the Barro and Lee 2001 data set). The formulas for the three levels of schooling for the labor force aged 15 and over are as follows:

$$HN_{0,t} = HN_{0,t-1} \cdot (1-\delta_t) + L15_t \cdot (1 - PRI_{t-1}) \tag{13}$$

$$HN_{1,t} = HN_{1,t-1} \cdot (1-\delta_t) + L15_t \cdot (PRI_{t-1} - SEC_t) \tag{14}$$

$$HN_{2,t} = HN_{2,t-1} \cdot (1-\delta_t) + L15_t \cdot SEC_t - L20_t \cdot TER_t \tag{15}$$

$$HN_{3,t} = HN_{3,t-1} \cdot (1-\delta_t) + L20_t \cdot TER_t \tag{16}$$

where

- HN_j = number of the economically active population for whom j is the highest level of schooling attained (j = 0 for no school, j = 1 for primary, j = 2 for secondary and j = 3 for higher education)
- PRI = enrollment ratio for primary education
- SEC = enrollment ratio for secondary education
- TER = enrollment ratio for tertiary education
- L = number of the economically active population
- $L15$ = number of persons aged 15
- $L20$ = number of persons aged 20
- $\delta_{h,t}$ = 'mortality rate' of the human capital stock.

The 'mortality rate' for the economically active population aged 15 and over is estimated from:

$$\delta_{h,t} \approx \frac{L_{t-1} - (L_t - L15_t)}{L_{t-1}} \tag{17}$$

And assumes that the mortality rate (which also includes the exit of the economically active population due to retirement or inactivity) is independent of the level of schooling attained, which is not entirely correct. The term L_t–$L15_t$ describes the number of survivals from the previous period, which are subtracted from L_{t-1} in order to estimate the total number of missing persons. Equation (5) as such describes the proportion of the labor force which did not survive from the previous period. The formulas can be rearranged to create the final equations that were used to generate the attainment ratios, hr_j, for the four broad levels of schooling for the economically active population aged 15 and over:

$$hr_{0,t} = \frac{HN_{0,t}}{L_t} = hr_{0,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L15_t}{L_t} \cdot (1 - PRI_{t-1}) \tag{18}$$

$$hr_{1,t} = \frac{HN_{1,t}}{L_t} = hr_{1,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L15_t}{L_t} \cdot (PRI_{t-1} - SEC_t) \tag{19}$$

$$hr_{2,t} = \frac{HN_{2,t}}{L_t} = hr_{2,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L15_t}{L_t} \cdot SEC_t - \frac{L20_t}{L_t} \cdot TER_t \tag{20}$$

$$hr_{3,t} = \frac{HN_{3,t}}{L_t} = hr_{3,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L20_t}{L_t} \cdot TER_t \tag{21}$$

The procedure requires school enrollment ratios that are crucial for exact calculations, but the proper accounting for Guatemala is not easy. Even though net enrollment ratios would be more precise for estimating the accumulation of human capital, gross enrollment ratios are used, as only this data is available. As reported in Table 8, the ratios are taken from various yearbooks of MINEDUC for the 1990s, UNESCO for earlier periods, and other sources available for Guatemala. The data for primary, secondary and tertiary enrollment ratios have been found consistent over time. Interpolation techniques were used to fill gaps in the data, but the use of this approach was kept to a minimum. The tertiary enrollment time series were more difficult to compile and required greater use of interpolated estimates.

In general, the estimated attainment data compares favorably with the census and survey information. The less accurate fit for 1981 is here believed to be due to large measurement errors or the possible manipulation of the census, which took place during the peak of the armed conflict in Guatemala. Consequently, this discrepancy was not smoothed over. Equally, data for 1998 differs slightly from the estimate. This is due to the fact that the survey largely oversamples the urban population of the economy in that year. Given the simplicity of the assumptions of the underlying model, however, the overall results have been found quite satisfactory.

In any case, simply employing gross enrollment ratios would overestimate the accumulation of human capital. Gross enrollment ratios are defined as the ratio of total enrollment in the respective schooling level to the population of the age group that is expected to be enrolled at that level. Thus, gross enrollment ratios can exceed 1 and therefore exaggerate the true amount of enrollment when students repeat, which is often the case in Guatemala.[14] In response to this problem and in order to benchmark the estimated educational attainment data with census and survey information, the gross enrollment ratios have been adjusted by a depreciation factor for the respective education level, as reported in Loening (2004b).

Finally, the formula to construct the measure for the human capital stock combines the estimated attainment data with the information on the duration of each schooling level. It is given as:

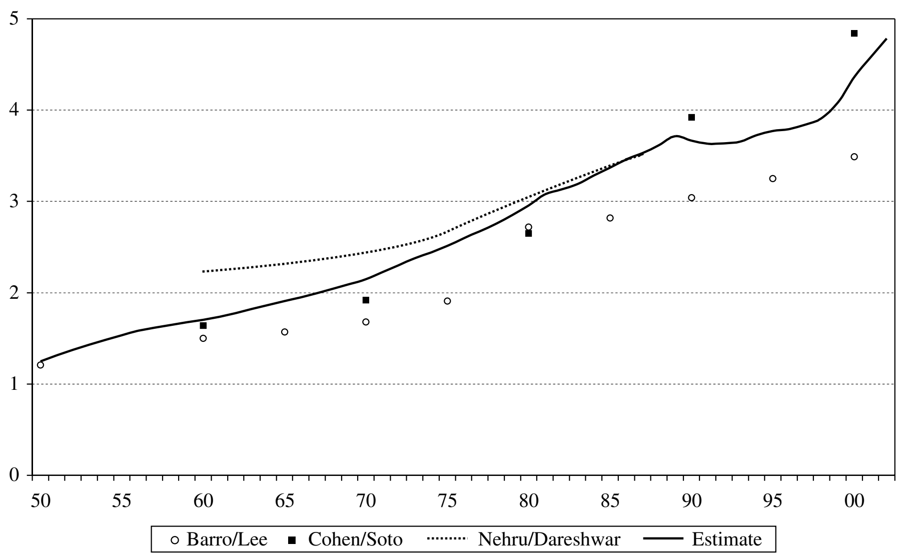
$$h_t = \sum_{j=1}^{3} hr_{j,t} \cdot d_{j,t} \tag{22}$$

where h_t stands for the average years of schooling, hr_j is the estimated attainment ratio of the labor force and d_j is the average number of years of education received in the respective schooling level j. Average education values have been calculated from the INE (1989) household survey and are assumed to have remained constant over time. This may result in a slight overestimate of the human capital stock for the period prior to 1989 and underestimate the average years of schooling for later periods. However, data from more recent household surveys suggest that this assumption may not be a large source of error.

How do these calculations compare to other sources? Figure 3 compares the results between the estimated average years of schooling here and those provided by Cohen and Soto (2002), Barro and Lee (2001), and Nehru *et al.* (1995), using different techniques and data sources. The time series shown by the solid line harmonizes to a large extent with alternative estimates at different points of time. Unlike the Barro and Lee data set, there is no implausible jump for 1980. The Cohen and Soto (2002) estimate provides the closest approximation. Additionally, not shown by Figure 3, the average years of schooling estimates here come close to values obtained from census and survey data. For example, Psacharopoulos and Arriagada (1986) report that mean education in the labor force was in the order of 1.7 for 1964. Edwards (2002) reports a value of 4.3 years for 2000. According to the estimate here, average years of schooling was in the order of 1.9 years in 1964 and 4.4 in 2000.

FIGURE 3

GUATEMALA: AVERAGE YEARS OF SCHOOLING IN LABOR FORCE, 1950-2002



Source: Author's estimate, and Barro and Lee (2001), Cohen and Soto (2001), Nehru *et al.* (1995) education data.

A closer look at Figure 3 yields two important descriptive outcomes. First, the data suggests that mean education evident in the labor force slightly declined during the early 1990s. This outcome is associated with the disastrous effect of the civil war on the country's human capital base. Those disadvantaged cohorts from the 1980s entered later into the labor force. Second, there has been substantial increase in the average years of schooling within the economically active population since 1998. This can be attributed to improvements within the education system and increased attention to education after the signing of the 1996 Peace Accords.

2. Labor Force

The measure of labor quantity here is the economically active population. For Guatemala there are several estimates. The National Statistic Institute (INE) provides calculations different from those of the Ministry of Work, both of which date back to 1980. Based on census and survey data, estimates for selected years have also been provided by the United Nations Development Programme (UNDP) for Guatemala. The labor force is usually defined as the working and job-seeking population, but the different calculations do not always reveal what underlies the specific assumptions and age definitions used for calculations. To develop a consistent time series of the economically active population, the International Labor Organisation (ILO) has used information on age specific labor force participation rates and population statistics. Unfortunately, for the reasons clarified below, these estimates are unreliable.

(1) *Data discrepancies*

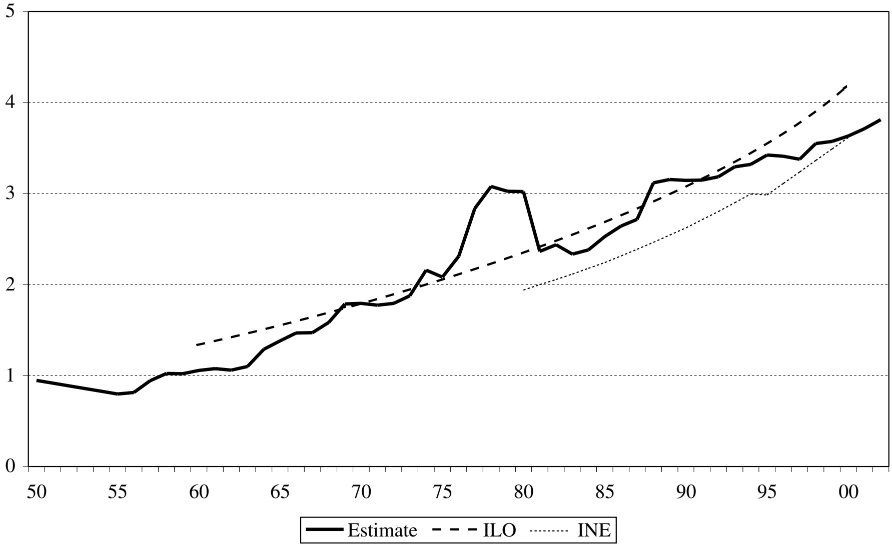
First, there is no agreement either on the level or on the growth rates of the labor force. Virtually all data is different from each other. For example, UNDP (2003a) reports a total labor force estimate of about 2.84 million for 1989, as compared to 2.54 million from INE or 2.95 million from ILO. Second, as typical for estimates in other countries, labor force data should show some cyclical fluctuations as labor responds to higher output growth. Official estimates for Guatemala, however, are remarkably free of *any* fluctuations and follow a monotonous trend. This suggests reliance on population statistics or use of interpolation techniques.

(2) *Omission of the civil strife*

Most importantly, these estimates do not take into account migration flows and the consequences of the civil war on the economically active population. Especially the last point devalues official estimates. According to the Commission for Historical Clarification (1999), the internal military conflict left an estimated 200,000 civilians dead and another one million displaced, for a total population of about 10 million. Such an immense impact of the civil strife should be reflected somewhere in the statistics?but it is not.

FIGURE 4

GUATEMALA: LABOR FORCE, 1950-2002
(Millions of workers)



Source: Author's estimate based on Banco de Guatemala (2003), INE and ILO data.

In the absence of reliable information about the economically active population from these sources, labor is here proxied by the number of private contributors to the Guatemalan Social Security System (IGSS). The reliance on the number of private contributors to the Social Security System in order to account adequately for the economically active population is also adopted in an IMF study for the case of El Salvador by Morales (1998), and for Guatemala by Prera (1999). The numbers representing the labor force are calculated by assuming that the social security contributors account for approximately 25 percent of the total labor force.[15] The participation rate has a negligible impact on the later calculations and is based on a historical mean value.

Although a broad approach may limit the precision of calculations, the regressions clearly show that the variable has a high explanatory power on growth. Moreover, as can be seen from Figure 4, the estimated values give a more reasonable picture than the data from official sources. Notice that the *level* of the economically active population, but not its growth rate, is basically in line with ILO or INE calculations. In 1980s, when the civil war had already taken genocide proportions, the labor force dropped dramatically by about 660,000.[16] For recent years, the estimate for the economically active population derived from IGSS statistics comes close to INE data.

3. Physical Capital Stock

Internationally, the Perpetual Inventory Method (PIM) is a common way to estimate capital stock, but there are uncertainties associated with the calculation. In general, due to the lack of information about the initial capital stock, questionable validity of assumptions about the rate of depreciation, and lack of information about the utilization of capital, estimates should be taken with care. With these reservations in mind, the PIM was used to construct the physical capital stock for Guatemala.

The physical capital stock that is used throughout the subsequent analyses is computed using the PIM with aggregated investment data. The procedure argues that the stock of capital is the accumulation of the stream of past investments:

$$K_t = K_{t-1} \cdot (1 - \delta_K) + I_t \tag{23}$$

where K is the capital stock, I gross fixed capital formation, δ_K the annual depreciation rate of the capital stock, and t an index for time. The initial value of the capital-output ratio for 1950 is taken from the Nehru and Dhareshwar (1993) data set.[17] Information about gross fixed capital formation was provided directly by the Economic Research Department of the Banco de Guatemala. The data is compiled using the somewhat dated 1953 UN System of National Accounts, which is currently under revision.[18] In line with other studies for Latin America, such as Loayza *et al*. (2004) and Morales (1998), the overall depreciation rate is assumed at 5 percent. This is still a rather high estimate when compared with more commonly used thumb values. However, regarding the armed conflict, which has lasted for 36 years, and several periods of high violence in Guatemala, it was found useful to adopt a high depreciation rate in order to account for both capital destruction and distraction from productive use. For example, the latter may have resulted in unprofitable military spending, several forms of non-productive investments, or temporary spare capital because of infrastructure deficiencies. The results of the regression analyses are not sensitive to moderate adjustments in the depreciation rate.

TABLE 10

GUATEMALA: TIME SERIES, 1950-2002

Years	Y	I	K	IM	EX	IM_{cap}	Mil_{exp}	L	h
	thousand of 1958 Quetzals							workers	years
1950	722344	81670	1086913	104911	91487	18124	5822	947442	1.249
1951	732525	79933	1112501	94472	82006	16018	5725	917001	1.315
1952	747724	68940	1125815	84967	91236	12812	6751	886560	1.374
1953	775292	67590	1137115	95080	93898	15428	6543	856118	1.430
1954	789610	67039	1147298	105768	87010	16300	6760	825677	1.483
1955	809107	90420	1180353	121559	97153	23842	8196	795236	1.534
1956	882711	142481	1263816	153196	105121	41275	8592	814288	1.583
1957	932494	154221	1354847	167210	111078	39731	9310	944152	1.618
1958	976055	136315	1423419	164338	121675	36581	9308	1022192	1.647
1959	1024223	125518	1477766	163049	145950	35063	9950	1020088	1.677
1960	1049199	107812	1511690	165231	152978	33094	9358	1056400	1.704
1961	1094267	113473	1549578	152933	156614	31847	9413	1076260	1.736
1962	1132984	108678	1580778	164752	162587	35528	9128	1059536	1.778
1963	1241064	128805	1630544	213401	223030	46771	11196	1099352	1.823
1964	1298557	157790	1706807	234186	214386	57591	9995	1289156	1.866
1965	1355156	166770	1788236	246955	242406	54065	14526	1382076	1.910
1966	1429923	165886	1864710	251070	297952	52302	15204	1467784	1.948
1967	1488609	184262	1955737	267088	278854	53353	16653	1469604	1.996
1968	1619203	209430	2067380	277748	313712	62055	15778	1583232	2.046
1969	1695892	212709	2176720	271794	353881	59445	15462	1786160	2.095
1970	1792754	209627	2277511	293287	346035	61002	27023	1793104	2.148
1971	1892832	227404	2391040	312071	360376	73122	17643	1771368	2.225
1972	2031552	226112	2497600	294733	412085	63183	18850	1793512	2.302
1973	2169378	251898	2624618	324212	451602	69372	17478	1875452	2.376
1974	2307675	247192	2740579	370700	481581	69703	19051	2159168	2.442
1975	2352750	270567	2874117	352057	497495	82220	25618	2082784	2.514
1976	2526537	371393	3101804	457126	530257	123898	27376	2311680	2.595
1977	2723844	405798	3352512	499819	563254	122124	33697	2835260	2.673
1978	2859913	435653	3620539	521600	562663	136120	35004	3076180	2.756
1979	2994650	413362	3852874	482783	619160	109077	39651	3024684	2.851
1980	3106877	372592	4032822	441194	651135	77301	42822	3022168	2.956
1981	3127560	401472	4232654	423061	557408	72579	47199	2364076	3.078
1982	3016573	357665	4378686	334288	510171	58520	56717	2436576	3.131
1983	2939604	258193	4417945	267857	454693	27213	59962	2334192	3.190
1984	2953546	234936	4431984	287205	440184	32933	63903	2379744	3.284
1985	2936062	220153	4430537	250278	454017	32763	58511	2526616	3.370
1986	2940175	228558	4437568	213598	390455	38735	48044	2641776	3.460
1987	3044395	266133	4481822	315784	413999	74773	49471	2715980	3.530
1988	3162873	299826	4557557	327741	437307	72815	49156	3118240	3.617
1989	3287594	318903	4648582	346883	495427	74471	47291	3153468	3.714
1990	3389552	286160	4702313	344322	527782	66684	40645	3143012	3.665
1991	3513627	296816	4764013	369249	502024	70072	41812	3147612	3.633
1992	3683616	385212	4911025	505961	543886	124052	45730	3182832	3.635
1993	3828260	411831	5077304	527335	596287	136596	41296	3292956	3.654
1994	3982682	401038	5224477	553498	616330	124076	43001	3321296	3.727
1995	4179767	435901	5399154	595513	693745	135417	41367	3422384	3.771
1996	4303395	427259	5556456	554652	754005	121748	35309	3408972	3.792
1997	4491199	523411	5802044	662824	815100	160200	33365	3377628	3.842
1998	4715468	614623	6126565	825223	834616	216859	34002	3548912	3.912
1999	4896875	650313	6470550	831098	873042	238777	33065	3572504	4.085
2000	5073597	593028	6740050	881261	906365	217171	41519	3632488	4.363
2001	5191941	603899	7006946	942247	870201	201074	48695	3711072	4.576
2002[p/]	5308677	634792	7291391	1004538	811532	230673	36132	3812208	4.784

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