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Instituto Ibero-Americano de Investigaciones Económicas
Ibero-America Institute for Economic Research
(IAI)

Georg-August-Universität Göttingen
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The Impact of Education on Economic Growth in Guatemala

Ludger J. Loening

June 2002

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The Impact of Education on Economic Growth in Guatemala: A Time-Series Analysis Applying an Error-Correction Methodology

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El crecimiento económico acelerado del país es necesario para la generación de empleos y su desarrollo social. El desarrollo social del país es, a su vez, indispensable para su crecimiento económico y una mejor inserción en la economía mundial. Al respecto, la elevación del nivel de vida, la salud de sus habitantes y la educación y capacitación constituyen las premisas para acceder al desarrollo sustentable en Guatemala.

Acuerdos de Paz

The Impact of Education on Economic Growth in Guatemala[1]

A Time-Series Analysis Applying an Error-Correction Methodology

Ludger J. Loening

Abstract

This paper investigates the impact of human capital on economic growth in Guatemala through the application of an error-correction methodology. Two channels are analyzed, by which human capital is expected to influence growth. A better-educated labor force appears to have a positive and significant impact on economic growth both via factor accumulation as well as on the evolution of total factor productivity. The results have been found robust concerning data issues and parameter stability.

JEL Classification Codes: I20, C22, C51, 054

Keywords: Education, Growth, Econometrics, Guatemala

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Contents

Figures

Tables

1. Introduction

Guatemala has enjoyed relative macro-economic stability during the past decades with average annual growth rates of about 4 percent. However, due to rapid population growth, per capita growth has averaged only about 1.2 percent per year. A continuation of this growth rate would imply that the average Guatemalan would need approximately 60 years to double his real income. According to World Bank (2002) estimates about 56 percent of Guatemala's population live in poverty. Economic growth could be one essential ingredient for expanding economic opportunities for poor people depending on innumerable factors, including the accumulation of human capital.

While there is a rather strong theoretical support for a key role of human capital in the growth process, empirical evidence is not clear-cut. In contrast to microeconomic studies which generally suggest significant returns to education on individual earnings, growth regressions on the macro level have often failed to find a significant and positive contribution of human capital to economic growth. The relationship between most measures of human capital and output growth has frequently been found surprisingly weak. Most evidence comes from cross-country regression samples of developing and industrial countries for various post-1960 periods. There is very little empirical analysis for individual countries. For the case of Guatemala there is no study that assesses the direct impact of education on economic growth.

The aim of this paper is to fill this gap and is divided into three sections. The first section presents the econometric methodology. The second part is concerned with data issues where particular focus is placed on the construction of the human capital stock that is defined by average years of schooling. The empirical results are discussed in the final section.

2. Methodology

The amount of empirical literature on economic growth is enormous. Among innumerable contributions there are two important empirical approaches which model the impact of human capital on output and economic growth. One way is to incorporate human capital as an additional factor within the production function, for example by adapting the Solow (1956) model. Up to now, this approach has remained the workhorse of empirical research. Mankiw, Romer and Weil (1992) show that traditional growth theory can accommodate human capital and may provide a reasonable approximation of cross-country data. Still, one of the key insights of the Solow model is that the factor accumulation per se is insufficient to achieve long-run growth, and that long-run growth particularly depends on growth in total factor productivity. 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 balanced growth path. Consideration of transition could therefore open up the possibility of assessing the macroeconomic role of education for economic growth within this framework. In addition, since the "short run" in the context of growth theory is often thought of in terms of decades, even short-run effects could be worthwhile policy objectives.

An alternative way, to some extent associated with endogenous growth, is to model explicitly technological progress as a function of the level of human capital and other variables. In a rather influential study, Benhabib and Spiegel (1994) first use the structural form of the human capital augmented production function to estimate the role of education for a sample of industrialized and developing countries. In their analysis, the regression coefficient on the change in average schooling years turns out to be statistically insignificant and sometimes even enters with a negative sign. Benhabib and Spiegel then propose an empirical growth model in which human capital externalities can be considered to be embodied in subsequent advances in education and in new physical capital via technology import as proposed in the models of Lucas (1988) and Romer (1990). Their empirical results suggest that the level of schooling, which enters with a positive coefficient, indeed facilitates the adoption of technology from abroad and the creation of domestic technologies. In a similar manner Morales (1998) shows that, among other variables, the completion of basic education proxied by enrollment ratios appears to have a significant and positive impact on total factor productivity within a time-series context for El Salvador. It is important to note that 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 the human capital stock. Implicit in this concept is the claim that by increasing the average level of education the rate of economic growth will be permanently increased over time.

Taking the above mentioned studies into account and given the fact that growth regressions have often led to disappointing results, the next paragraphs provide the empirical specification for the two different channels through which education is assumed to influence economic growth. The first model treats human capital as an additional factor of production while the second model hypothesizes that human capital levels directly affect the aggregate technology parameter.

Model 1: Human Capital as a Factor of Production

The human capital augmented growth 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

(1) $$Y = A \cdot K^{\alpha} \cdot H^{\beta} \cdot L^{(1-\alpha-\beta)}$$

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 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

$$(2) \qquad \ln y_t = \ln A + \alpha \cdot \ln k_t + \beta \cdot \ln h_t + u_t$$

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 it is well known that most macroeconomic time-series contain unit roots and that regression of one non-stationary series on another is likely to yield spurious results. As reported in the appendix, the data for the case of Guatemala is no exception. By transforming the time-series to stationarity by first differencing, the estimation bias will be removed. However, in any case this will create its own problems, notably because of the risk of losing 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 also been used successfully in alternative growth studies. Examples of this are Nehru and Dareshwar (1994), Morales (1998) and Bassanini and Scarpetta (2001). The error-correction model may be estimated in two 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. In order to estimate the human capital augmented production function, the error-correction model may be written as follows:

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

As it stands, this equation cannot be estimated by Ordinary Least Squares since the variables in parenthesis cannot be formed without knowledge of α and β. However, one can estimate the re-parameterized form:

$$(4) \quad \Delta \ln y_t = \ln A + \gamma_1 \cdot \Delta \ln k_t + \gamma_2 \cdot \Delta \ln h_t \ldots + \gamma_3 \cdot \ln y_{t-1} + \gamma_4 \cdot \ln k_{t-1} + \gamma_5 \cdot \ln h_{t-1} + \gamma_6 \cdot DUMMY_t + u_t$$

Estimates of the parameter γ_3 can be used to calculate the required elasticities α and β. The 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 the case of Guatemala, it was found useful to include a dummy variable into the error-correction model in order to test and eventually correct for the deviations of the long-run trend on output growth stemming from the civil strife.

Once the overall model fit has been found satisfactory, equation (3) is reformulated in order to incorporate an error-correction term. Engle and Granger (1987) suggest a so-called "two-step" procedure, in which the error-correction term EC_{t-1} is derived from the lagged residuals u_t of the levels regression in equation (2) that can be used to estimate the model:

$$(5) \quad \Delta \ln y_t = \ln A + \gamma_1 \cdot \Delta \ln k_t + \gamma_2 \cdot \Delta \ln h_t + \gamma_3 \cdot EC_{t-1} + \gamma_4 \cdot DUMMY_t + u_t$$

Equations (4) and (5) should in principle produce similar results, because both formulations can be understood as a transformation of each other. They may therefore yield information about the robustness of the estimated coefficients.

Model 2: Human Capital Affecting the Technology Parameter

The basic framework for the second specification is a standard Cobb-Douglas production function with constant returns to scale

$$(6) \qquad Y = A \cdot K^{\alpha} \cdot L^{(1-\alpha)}$$

which is standardized by labor units in order to avoid multicollinearity between capital and labor. Converted into a logarithmic expression, the equation becomes:

$$(7) \qquad \ln y_t = \ln A + \alpha \cdot \ln k_t + u_t$$

Combining the long-run information of the variables with a short-run adjustment mechanism, the equation can be represented in its error-correction form:

$$(8) \qquad \Delta \ln y_t = \gamma_1 \cdot \Delta \ln k_t - \gamma_2 \cdot (\ln y_{t-1} - \alpha \ln k_{t-1} - \ln A)$$

In contrast to the human capital augmented growth model however, total factor productivity is considered to be a function of exogenous variables, namely education and foreign inputs. Benhabib and Spiegel (1994) postulate that an educated labor force may play a key role in determining productivity rather than entering on its own as a production factor. In the interest of simplicity, they assume that human capital is exogeneously given and that higher levels of h cause increased productivity. Benhabib and Spiegel follow Romer (1990) and

Nelson and Phelps (1966). In their empirical growth model human capital affects total factor productivity through two channels. First, higher levels of human capital directly influence productivity via its impact on domestic innovation. Secondly, higher levels of human capital cause improvements in total factor productivity by facilitating the adoption and implementation of foreign technology and therefore reducing the knowledge gap between the technologically leading nations and the developing world. In addition, along with many other authors, Lee (1995) emphasizes that relatively cheaper foreign inputs are important determinants of growth since they provide a wider range of intermediate inputs (which in turn might enhance technological progress) and affect the efficiency of capital accumulation. Using cross-country data, Lee shows that the ratio of imports in investment has a significant positive effect on economic growth. Taking into account these studies, the technology parameter is treated as a non-constant and is allowed to change over time

$$(9) \qquad \ln A = c + \gamma_4 \cdot \ln h_t + \gamma_5 \cdot \frac{IM_t}{I_t} + \gamma_6 \cdot DUMMY_t$$

where c is a constant or exogenous technological progress, h represents the level of human capital proxied by average years of schooling, and IM/I is the ratio of total imports to gross domestic investment. Moreover, the effects of civil strife and periods of high violence which are assumed to have a negative impact on productivity and output growth are tested by the dummy variable. Combining equations (8) and (9) yields the "one step" error-correction model in its re-parameterized form:

$$(10) \quad \Delta \ln y_t = c + \gamma_1 \cdot \Delta \ln k_t + \gamma_2 \cdot \ln y_{t-1} + \gamma_3 \cdot \ln k_{t-1} \ldots + \gamma_4 \cdot \ln h_t + \gamma_5 \cdot \frac{IM_t}{I_t} + \gamma_6 \cdot DUMMY_t + u_t$$

In analogy to the first empirical model, one can also apply a "two step" procedure using the lagged residuals of the level regression from equation (7) and incorporate an error-correction term into the specification:

$$(11) \quad \Delta \ln y_t = c + \gamma_1 \Delta \cdot \ln k_t + \gamma_2 \cdot EC_{t-1} \ldots$$
$$+ \gamma_3 \cdot \ln h_t + \gamma_4 \cdot \frac{IM_t}{I_t} + \gamma_5 \cdot DUMMY_t + u_t$$

Notice that the final equations are quite similar when compared with the human capital augmented model. Therefore, it may be difficult to distinguish empirically between the two approaches. However, the meaning of the alternative model 2 in terms of its implication is that the *level* of human capital rather than the *growth rates* now play a role in determining the growth of output per worker.

Table 1:
Comparison of Indicators Related to Human Capital

	Guatemala	Nicaragua	Honduras	El Salvador	Costa Rica	Average for Latin America
Public spending on education (percent of GDP) (1995)	1.7	3.7	3.6	2.2	4.6	NA
Average years of schooling (1995) (population 15-64)	3.3	4.1	4.5	4.7	5.8	5.9
Primary school net enrollment (1997)	73.8	78.6	87.5	89.1	91.8	93.3
Secondary school net enrollment (1997)	34.9	50.5	36.0	36.4	55.8	65.3
Adult illiteracy (1998)	32.7	32.1	26.6	22.2	4.7	12.3
Infant mortality (per 1000 births) (1998)	41.0	39.0	33.0	30.0	14.0	32.0
Life expectancy at birth (years) (1998)	64.4	68.1	69.6	69.4	76.2	69.7

Source: Barro and Lee (2000) for average years of schooling and UNDP (2000).

Growth of output per worker now depends positively upon the average level of human capital through its impact on productivity. As table 1 and the next section point out, despite some efforts in increasing average years of schooling, Guatemala's human capital base still remains far behind the Latin American average. If these equations are significant, they could yield information about the low performance of Guatemala's economy in terms of per capita growth.

3. Data Sources and Estimates

Since Guatemala is very deficient in data, the identification of the macroeconomic impact of education on economic growth indicates the need to overcome data constraints. However, the underlying argument is that coherent results can still be obtained. It is important to note that a significant fraction of the economic activity in Guatemala can be found in the informal sectors. CIEN (2001) reports that at least ⅓ of Guatemala's economic activities are in the informal sectors. Since this lack of documentation and uncertain data probably does not affect all factors equally, there is a potential bias within the time-series which cannot be accounted for.

Capital Stock and Output

A common way to estimate the capital stock is to use the perpetual inventory method, but there are considerable uncertainties associated with the process. Due to the lack of information about the initial capital stock, as well as the questionable validity of assumptions about the rate of depreciation and the frequent lack of information about its utilization and quality, capital stock estimates should be made with care. With this in mind, the perpetual inventory method was used to construct the physical capital stock for Guatemala.[2] The procedure argues that the stock of capital is the accumulation of the stream of past investments

(12) $K_t = K_{t-1} \cdot (1-\delta) + I_t$

where K is the capital stock, I is the gross fixed capital formation, δ the annual depreciation rate of the capital stock and t an index for time. Information about the gross fixed capital formation and the GDP has been obtained directly from the Economic Research Department of the Central Bank of Guatemala. The data is compiled using the outdated 1953 United Nations System of National Accounts which is currently under revision within the bank. The initial value of the capital-output ratio for 1950 is taken from the Nehru and Dhareshwar (1993) data set. In line with many other studies such as that of Prera (1999), and Morán and Valle (2001), the overall depreciation rate is assumed to be 5 percent. This is still a rather high estimate when compared with more commonly used thump values. However, regarding the armed conflict which has lasted for more than 35 years and several periods of high violence levels in Guatemala, it was found useful to adopt a high depreciation rate in order to account for both capital destruction and capital distraction from productive uses. 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 following regression analysis are not sensitive to moderate adjustments in the depreciation rate.

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2 Nehru and Dhareshwar (1993) offer an alternative estimate of the capital stock for Guatemala which leads to similar regression results, despite a low depreciation rate and some discrepancies on investment data and output when compared with information from Banco de Guatemala (2001). Other estimates include Prera (1999) and Morán and Valle (2001). Because of relatively short time periods and other shortcomings these two sources have not been taken into consideration.

Labor Force

The measure of quantity of labor 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. The labor force is usually defined as the working and job-seeking population. Their calculations do not always reveal what underlies the specific assumptions and age definitions. To develop 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. All these estimates do not take into account migration flows and the behavior of the economically active population during the civil war. Based on census and survey data, a potentially more accurate estimate has been provided since 1995 by the United Nations Development Program (PNUD) for Guatemala.

In absence of reliable long-term information about the economically active population, labor is proxied by the number of private contributors to the Guatemalan Social Security System (IGSS). This is done by assuming a constant share of 25 percent in the total labor force for the time period under consideration. 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 Morales (1998) and Prera (1999). Of course, this approach is fairly crude and may seriously limit the precision of the econometric estimates. Still, as can be seen from Figure 1c, the estimated values seem to give a more reasonable picture than that of the data from official sources which completely ignore migration and are remarkably free of fluctuations. Notice that the estimate for the economically active population derived from IGSS statistics comes very close to the PNUD estimate for the last two years.

Human Capital Stock

The human capital stock of Guatemala is defined by average years of schooling evident in the labor force. Because human capital is multifaceted and includes a complex set of human attributes, 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. Although years of schooling are currently the most commonly employed measure, it is problematic for at least two reasons. First, years of schooling do not raise human capital by an equal amount regardless of whether a person is enrolled in a primary, secondary or tertiary schooling level. Secondly, average years of schooling measures do not take into account quality changes within the educational system. This makes it difficult to interpret inter temporal comparisons. In terms of data availability it seems difficult to account for the quality of educational patterns for Guatemala. But at least, the first point deserves some attention.

Defining human capital by average years of schooling 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 (1994) suggests that the rates of return could be decreasing with the acquisition of additional schooling. Therefore, in order to achieve a conceptually better measure of the human capital stock, average years of schooling can be weighted differently depending on how many years of schooling a person has already accumulated. Several attempts have been made to construct human capital measures by combining average years of schooling with rates of return estimated in micro labor studies. Notice that using educational rates of return can also be subject to criticism because there are likely to be potential biases of unmeasured characteristics. During the preliminary steps of this analysis, an attempt was made to construct an index of educational attainment as found in Bosworth et al. (1996). In the case of Guatemala employing average years of schooling or a weighted human capital index based on earning differentials would not cause significant change in the latter regression results. In conclusion, the average years of schooling may provide a reasonable approximation of the human capital stock which has the advantage of being interpreted more easily.

Having made some modifications to account for the statistical circumstances in Guatemala, the following procedure for constructing estimates of the human capital stock is based on the work of Barro and Lee (2000). The use of a perpetual inventory method that employs census and survey information on educational attainment as benchmark figures can be seen as a major advantage over other studies. The benchmarks are taken from various national censuses and surveys and are reproduced in the appendix. 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 of educational attainment, that is, no school, some primary, some secondary and some tertiary education.

The procedure starts to construct current flows of adult population which are added to the initial benchmark stocks of the labor force. The formulas for the three levels of schooling for the labor force aged 15 and over are as follows:

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

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

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

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

where

H_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 school
SEC	=	enrollment ratio for secondary school
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
δ_t	=	mortality rate of the human capital stock.

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

(17) $\delta_t \approx \frac{L_{t-1} - (L_t - L15_t)}{L_{t-1}}$

and assumes that the mortality rate (and migration flows) are 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 assess the total number of missing persons. Equation (17) 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 for the four broad levels of schooling for the economically active population aged 15 and over:

$$(18)\quad h_{0,t} = \frac{H_{0,t}}{L_t} = h_{0,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L15_t}{L_t} \cdot (1 - PRI_{t-1})$$

$$(19)\quad h_{1,t} = \frac{H_{1,t}}{L_t} = h_{1,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L15_t}{L_t} \cdot (PRI_{t-1} - SEC_t)$$

$$(20)\quad h_{2,t} = \frac{H_{2,t}}{L_t} = h_{2,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L15_t}{L_t} \cdot SEC_t - \frac{L20_t}{L_t} \cdot TER_t$$

$$(21)\quad h_{3,t} = \frac{H_{3,t}}{L_t} = h_{3,t-1} \cdot \left(1 - \frac{L15_t}{L_t}\right) + \frac{L20_t}{L_t} \cdot TER_t$$

The procedure requires school enrollment ratios which are crucial for exact calculations, but the proper accounting for Guatemala is somewhat problematic. Even though net enrollment ratios would be more precise for estimating the accumulation of human capital, gross enrollment ratios are used in terms of data availability. As reported in the appendix, the ratios are taken from various yearbooks of the Guatemalan Ministry of Education for the 1990s, the United Nations Educational, Scientific and Cultural Organization (UNESCO) for earlier periods and other sources available for Guatemala. The sources 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 series were more difficult to compile and required greater use of interpolated estimates. Nevertheless, the potential measurement bias is believed to be unimportant considering the small participation of this group within the labor force.

In any case, simply employing gross enrollment ratios would overestimate to a large extent 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 one and therefore exaggerate the true amount of enrollment when students repeat which is often the case in Guatemala.

In response to this problem and in order to benchmark the estimated educational attainment time-series with census and survey information, the gross enrollment ratios have been adjusted by a depreciation factor for the respective educational level which are reported in the appendix. As can be appreciated from table 6, the estimated attainment data compares favorably with the census and survey information. The less accurate fit for 1981 is believed to be due to large measurement errors of the census, taking place during the peak of the armed conflict in Guatemala and was therefore not corrected. Given the rather mechanical approach used to construct the distribution of educational attainment among the population and the simplicity of the assumptions, the results have been found satisfactory.

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 and is given as

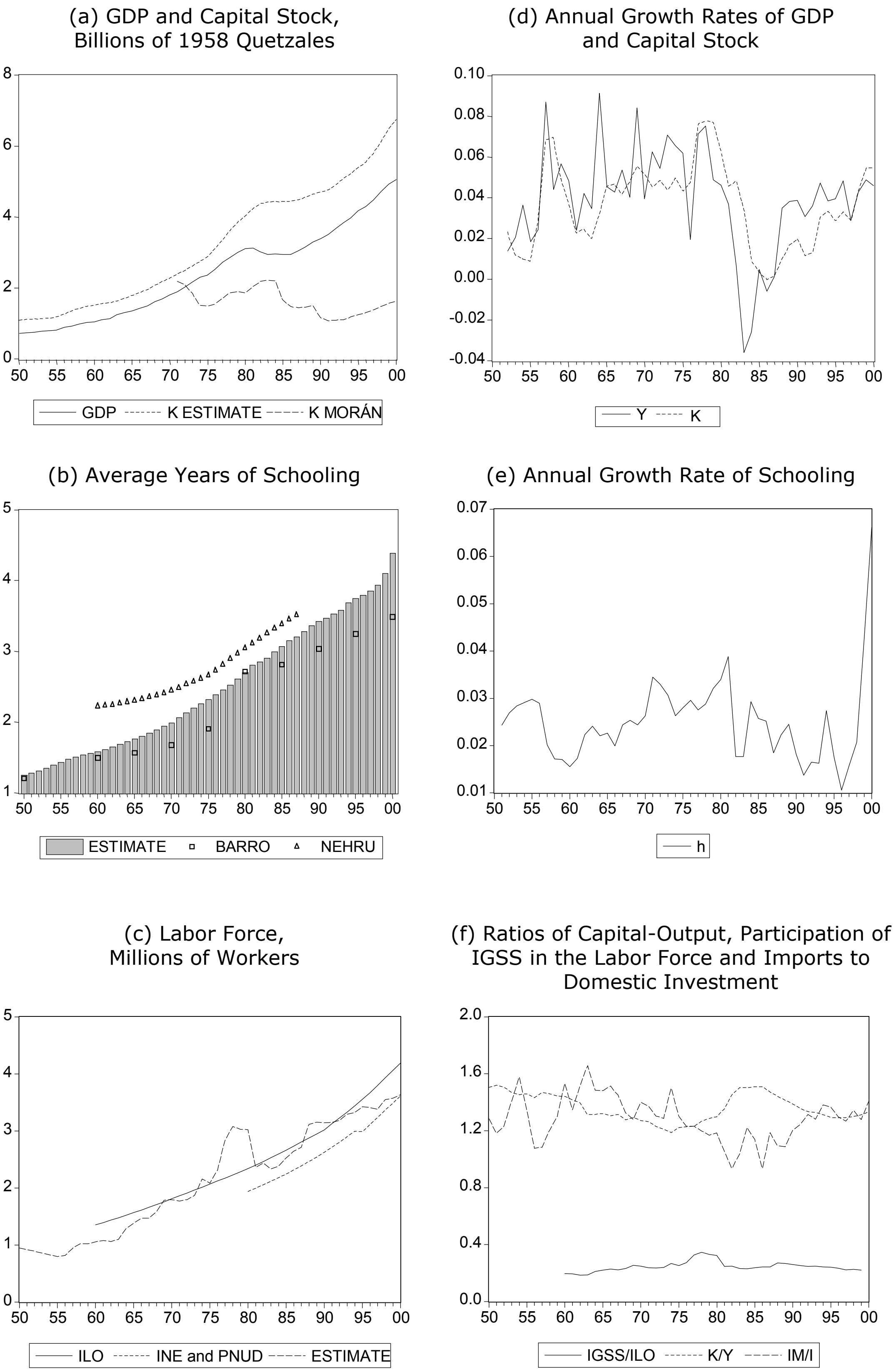
$$(22) \quad h_t = \sum_{j=1}^{3} h_{j,t} \cdot d_{j,t}$$

where h_t stands for the average years of schooling, h_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 *Encuesta Nacional Socio-Demográfica* from 1989 and are assumed to have remained constant over time. This may result in a slight overestimate of the human capital stock for the period before 1989 and underestimate the average years of schooling for the 1990s. However, data from *the Encuesta Nacional de Ingresos y Gastos Familiares* from 1998/99 suggest that this assumption may not be a large source of error.

How reliable are these estimates? The correlation coefficients between the estimated average years of schooling here and those provided by Barro and Lee (2000) and Nehru et al. (1995), using different techniques and data sources, all exceed 0.95 in the case of Guatemala. Figure 1b compares the results. The data seems to harmonize to a large extent with these alternative estimates. Unlike the Barro and Lee data set, there are no implausible jumps for 1980 and the data already takes into account improvements in the educational system during the 1990s. Additionally, the average years of schooling estimates come close to values obtained from census and survey data that are in the order of 1.7 for 1964 and 3.1 for 1989 (see Psacharopoulos and Arriagada 1986 and World Bank 1995: Appendix A).

Interestingly, there is a substantial increase in the average years of schooling within the economically active population since 1998 which may be attributed to improvements within the educational system and increased human capital investment. Even so, there is little dispute of the fact that educational attainment in Guatemala still remains among the lowest while compared to other Latin American countries (see table 1 and World Bank 1996:5, 1995:31). Guatemala appears to spend less on education than any other country in the region. According to the Inter-American Development Bank, the educational gap between Guatemala and other Latin American countries is currently widening (see IDB 2001:11).

Figure 1:
Evolution of Capital, Labor and Schooling



4. Empirical Results

The starting point of the empirical investigation is given by the univariate analysis of the time-series. The data is displayed in figure 1. Nearly all time-series show permanent growth over time. The only exception is the economically active population which appears to be strongly influenced by business cycles and other factors. Also obvious is the dramatic breakdown of economic activity during the 1980s which can be attributed to an adverse macroeconomic environment and the peak of the civil war during that period. To the extent that the explanatory variables do not fully explain these effects, a dummy variable was included for the years 1977-1986. CIEN (2002) and other sources have recently reported fairly high levels of violence for the country. Therefore, the dummy variable was extended to the year 2000. Attempts were fruitless to include alternative control variables such as inflation, real interest and exchange rates, public sector deficit, exports, international coffee prices or a linear trend which might be related to growth in order to stabilize the regressions. The dummy turned out to be highly significant in all specifications. Consequently, it was considered to be appropriate to capture otherwise unmeasurable deviations from the long-run trend on output growth.

Overall Results

Figures 2d-e show the fitness of equations (4) and (10). The adjusted R^2 in all specifications of the error-correction model is rather high indicating a good fitting of the respective model to the data. Test statistics do not point out any evidence of serial correlation nor misspecification at conventional levels. The residuals have been found normally distributed following stationary patterns. Both specifications of the error-correction model lead to similar results although the "one step" procedure is the preferred one. Considering the simplicity of the assumptions for the construction of the capital, labor and human capital stocks in the context of data uncertainties and distortions caused by the internal military conflict and the limited choice of explanatory variables, the results have been found acceptable. Gradually, the empirical specification that hypothesizes that human capital affects the technology parameter (model 2) performs slightly better and its results have been found more robust concerning parameter stability than the human capital augmented production function (model 1). The error-correction coefficient in all specifications is statistically significant and suggests a moderate speed of adjustment towards the long-run growth path, equal to about 13 to 16 percent of the deviations per year. After a certain shock to the economy it would take on the average approximately 20 years to reach the level of output consistent with long-run growth (with differences to be less than 5 percent). The estimated capital share in output is approximately ½ to ³⁄₅ and was found consistent with the empirical evidence for developing countries. The most striking result for Guatemala is however, that in both empirical models the average years of schooling appear to be strongly correlated with per capita growth.[3]

Model 1: Human Capital as a Factor of Production

Human capital as a production factor measured by average years of schooling, appears to have a positive and significant impact on the growth of output per worker. The estimated long-run effect of a 1 percent increase of the average years schooling on GDP per unit of labor is approximately 0.16 percent. The schooling coefficient has been found robust concerning alternative assumptions about the physical and human capital stock. Employing alternative data would not change

[3] Since the residuals of both regressions are stationary, it can be concluded that cointegration is accepted. This means that there is a unique long-run relationship of GDP per worker to the average years of schooling indicator. This result can be confirmed using the Johansen cointegration methodology as reported in the appendix.

the magnitude nor the significance of the variable. The short-run elasticity of schooling is more difficult to explain. It is questionable whether or not that education has short-term effects on growth. A possible interpretation of this correlation could be that an increase in the average years of schooling partly behaves as a proxy for improved expectations, as emphasized by Morales (1998). Another possibility for the increase could be reverse causality effects. In other words, periods of increased enrollment in education are more favorable to higher rates of short-run growth. Figures 2a-c compare the evolution of enrollment ratios and GDP in Guatemala without carrying this interpretation too far. The data seems to support this hypothesis. However, the relationship appears to be more clear-cut for the secondary and the tertiary than for the primary enrollment ratios. Regarding the quality and heterogeneity of the data sources for the gross enrollment ratios, the short-term schooling coefficient was found to be sensitive to data issues. Consequently, its magnitude must be interpreted with care.

The long-run relationship of output with respect to its explanatory variables can be derived from equation (4) in table 2. The results in terms of the human capital augmented Cobb-Douglas production function are the following:

$$(23) \quad Y = A \cdot K^{0.547} \cdot H^{0.163} \cdot L^{0.290}$$

A starting point for investigating the basic facts of economic growth is often the examination of its sources applying a traditional Solow (1957) decomposition. The production function elasticities can give estimates of factor shares that are used subsequently to weigh the relative contribution of the growth rates of inputs and to obtain straightforward estimates of total factor productivity

$$(24) \quad \Delta \ln A = \Delta \ln Y - \alpha \cdot \Delta \ln K - \beta \cdot \Delta \ln H - (1 - \alpha - \beta) \cdot \Delta \ln L$$

Table 2:

Production Function for Guatemala: Human Capital as Factor Input

	Dependent variable: percent change of GDP/worker	
	Equation (4)	Equation (5)
Constant	-0.038* (-2.12)	-0.002 (-0.26)
Percent change of capital/worker	0.900** (22.2)	0.904** (23.9)
Percent change of schooling/worker	0.483+ (1.57)	0.486+ (1.62)
ln GDP/worker [-1]	-0.132** (-2.90)	
ln capital/worker [-1]	0.072* (2.02)	
ln average schooling [-1]	0.022* (2.01)	
Dummy	-0.032** (-4.95)	-0.032** (-5.34)
Error term [-1]		-0.131** (-2.95)
Long-run elasticity of capital	0.547	0.547
Long-run elasticity of schooling	0.163	0.163
Adjusted R^2	0.933	0.936
F-statistic	114.8	179.7
Durbin-Watson	1.942	1.931
S.E. of regression	0.016	0.016
N	50	50

t-statistics in parenthesis.

+ significant at the 10 percent level.
* significant at the 5 percent level.
** significant at the 1 percent level.

where Δ ln stands for the logarithmic differential (or the growth rate) of the respective variable. Growth accounting can be very informative by providing a consistent decomposition of economic growth among its proximate sources. However, several caveats should be kept in mind. Estimates of Solow residuals are very sensitive to measurement errors, adjustments to factor inputs for utilization and quality, as well as to the precision of the estimated factor shares. In addition, findings in the area of growth accounting require careful interpretation because the concept does not provide information about the interdependencies of the variables. For instance, an increase of output growth could be due to a percentage change in educational attainment. This would not imply that, in the absence of educational improvements, the growth rates would have been precisely the same percentage point lower. Education could impact on output growth due to fertility, attitudes and labor force participation, investment and the growth of total factor productivity.

Table 3:
Sources of Economic Growth in Guatemala

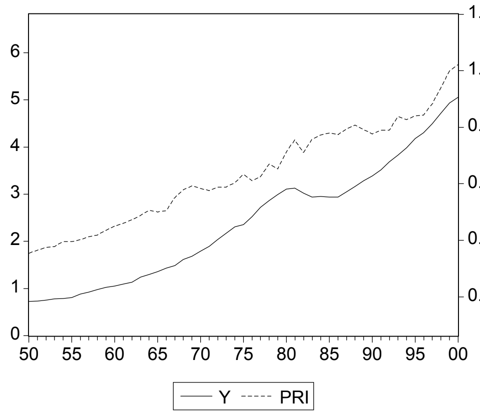
	Growth of GDP	Contributions of			
		Capital	Labor	Education	TFP
1951-00	3.89	2.00	0.78	0.85	0.27
		(51%)	(20%)	(22%)	(7%)
1951-75	4.72	2.13	0.91	0.92	0.76
1976-85	2.21	2.37	0.56	0.77	-1.49
1986-00	3.63	1.53	0.70	0.78	0.61

Table 3 suggests that growth in the Guatemalan economy is largely due to the accumulation of inputs. The average annual growth rate during the last 50 years has been about 3.9 percent. Capital formation has played the dominant role in explaining approximately 50 percent of Guatemala's growth rate of GDP, followed by the accumulation of

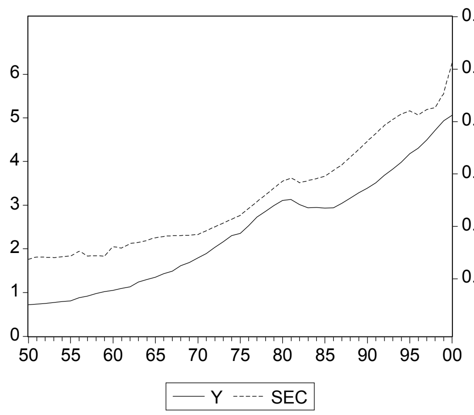
Figure 2:

Evolution of Enrollment Ratios with Respect to GDP, Model Fit and Total Factor Productivity

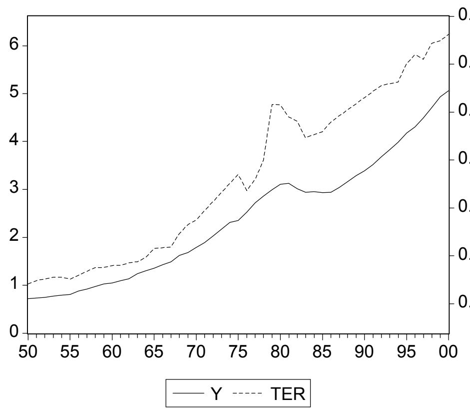
(a) Primary Gross Enrollment Ratio and GDP, Billions of 1958 Quetzales



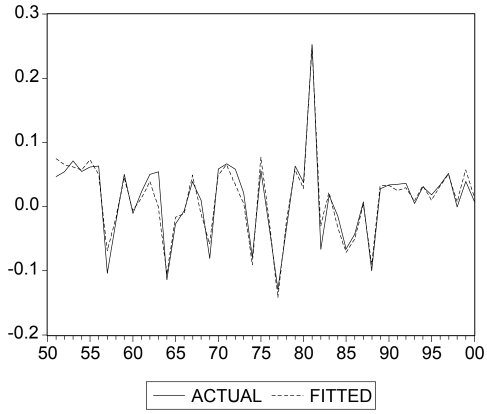
(b) Secondary Gross Enrollment Ratio and GDP, Billions of 1958 Quetzales



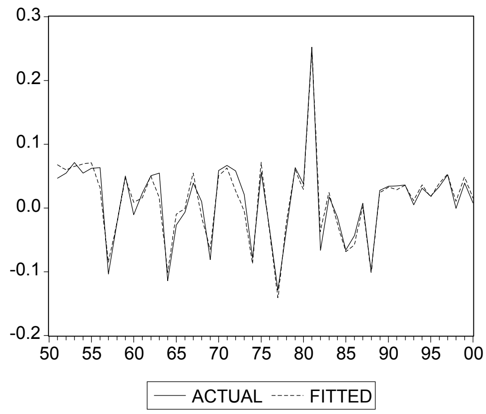
(c) Tertiary Gross Enrollment Ratio and GDP, Billions of 1958 Quetzales



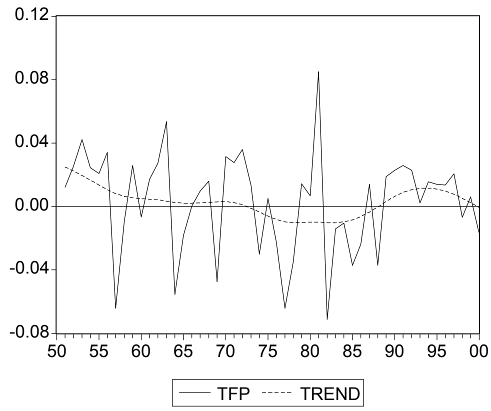
(d) Actual versus Fitted Growth of GDP per Worker, Model 1



(e) Actual versus Fitted Growth of GDP per Worker, Model 2



(f) Growth Rate of Total Factor Productivity, Model 1



human capital and labor force growth. The contribution of human capital may be understated because the average-years-of-schooling measure does not take into account elements such as the quality of schooling, learning-by-doing and the health and nutrition status of the population. The contribution of total factor productivity (TFP) is relatively small at less than 10 percent. Productivity growth appears to be volatile according to figure 2f. In order to interpret the results, a trend line was included using the Hodrick-Prescott filter. Productivity seems to have been positive, although decreasing until the mid-1970s. This was followed by a substantial deterioration in the advent of civil war. In the 1990s, total factor productivity growth became positive again, but eventually decreased to zero growth in 2000. Overall, within the chosen framework, one can conclude that over the medium-term human capital accumulation plays an important role for economic growth in Guatemala. However, faster long-term growth would depend crucially on Guatemala's ability to increase productivity. In this respect, the results of the following empirical specification may provide useful insights.

Model 2: Human Capital Affecting the Technology Parameter

The second empirical model emphasizes that the average level of schooling should not be treated as an extra input into the production function but may directly affect total factor productivity. Based on the regression results of equation (10) in table 4, the following formulas in terms of the Cobb-Douglas production function can be obtained:

(25) $$Y = A \cdot K^{0.586} \cdot L^{0.414}$$
$$\ln y = \ln A + 0.586 \cdot k$$

(26) $$\ln A = -0.717 + 0.179 \cdot \ln h_t + 0.355 \cdot \frac{IM_t}{I_t} - 0.115 \cdot DUMMY_t$$

(27) $$\Delta \ln y_t = 0.917 \cdot \Delta \ln k_t - 0.164 \cdot (\ln y_{t-1} - 0.586 \cdot \ln k_{t-1} - \ln A)$$

Table 4:

Production Function for Guatemala: Human Capital Affecting the Technology Parameter

	Dependent variable: percent change of GDP/worker	
	Equation (10)	Equation (11)
Constant	-0.117** (-3.83)	-0.080** (-3.12)
Percent change of capital/worker	0.917** (25.8)	0.940** (28.0)
ln GDP/worker [-1]	-0.164** (-3.86)	
ln capital/worker [-1]	0.096** (2.89)	
ln average schooling	0.029** (2.92)	0.017* (2.30)
Ratio of imports/gross domestic investment	0.058** (3.45)	0.057** (3.28)
Dummy	-0.019** (-3.10)	-0.020** (-3.25)
Error term [-1]		-0.130** (-3.37)
Long-run elasticity of capital	0.586	0.586
Adjusted R^2	0.945	0.942
F-statistic	140.7	160.8
Durbin-Watson	2.082	1.978
S.E. of regression	0.015	0.015
N	50	50

t-statistics in parenthesis.

* significant at the 5 percent level.
** significant at the 1 percent level.

Equation (25) expresses the production function in the long run, equation (26) displays the variables that are thought to explain the evolution of total factor productivity and equation (27) shows the short-term dynamics of growth per labor unit. Notice that the estimated production elasticity of physical capital in the long-run equation is now larger than its factor share (as estimated in the human capital augmented production function) reflecting its correlation with human capital.

Taken at face value, model 2 provides two mechanisms that govern the evolution of total factor productivity. First, the level of human capital, as measured by average years of schooling, appears to have a highly significant and positive impact on productivity growth in Guatemala. Secondly, the empirical results imply that foreign inputs are quite important determinants for productivity growth through the implementation of foreign technology. The ratio of total imports to domestic investment may hold as an indicator for the quality of investment. Almost obvious is the finding that periods of high violence or political instability, as proxied by the dummy variable, influence negatively the efficient use of factor inputs and economic growth.

Interestingly, the schooling variable and the ratio of imports to investment proved to have some joint effects. That is, the empirical specification works best when both variables are included within the equation. Employing the variables on their own would slightly reduce their significance. This effect could imply that there is an additional role for education in order to attract physical capital. Lucas (1990) has suggested an alternative channel for human capital to growth. One reason why physical capital does not flow to poor countries may be the fact that these countries are typically poorly endowed with factors complementary to physical capital, thereby reducing its rate of return.

5. Concluding Summary

After constructing the required time-series, this paper investigated the impact of human capital on economic growth in Guatemala through the application of an error-correction methodology. Two channels were analyzed, by which human capital is hypothesized to influence growth. However, it is empirically difficult to separate both approaches.

First, a better-educated labor force appears to have a positive and significant impact on economic growth via factor accumulation. Over the medium run, a 1 percent increase of the average years of schooling would raise output per worker by about 0.16 percent. However, long-run growth depends on Guatemala's ability to increase productivity.

Secondly, the average level of human capital appears to have a strong impact on the evolution of total factor productivity. Therefore, one reason for the low performance of the economy in terms of per capita growth may be attributed to Guatemala's poorly developed human capital base lagging far behind the Latin American average. The empirical results in this study have some policy implications. In particular, they underscore the need for further efforts in Guatemala to increase its level of human capital.

Given the incomplete character of the average-years-of-schooling measure and the potential existence of threshold levels in education, as well as numerous non-monetary benefits of education, the contribution of human capital may be underestimated in its quantitative form. Regarding the modest growth of total factor productivity in Guatemala, an additional finding is that the composition of investment appears to be an important factor behind productivity growth. The results have been found robust concerning data issues and parameter stability.

6. Resumen

Después de construir las series de tiempo requeridas, este trabajo trató el impacto del capital humano en el crecimiento económico de Guatemala, a través de la aplicación de un modelo de corrección de errores. Dos vías fueron analizadas, por las cuales capital humano supone la influencia en el crecimiento. Sin embargo, es empíricamente difícil separar ambas aproximaciones.

Primero, una fuerza de trabajo mejor educada presenta un impacto positivo y significativo en el crecimiento económico vía acumulación de factores. En el mediano plazo, un aumento del 1% del promedio de años de escolaridad aumentaría la cantidad producida por trabajador al rededor del 0.16%. Sin embargo, el crecimiento en el largo plazo depende de la capacidad de Guatemala para aumentar la productividad.

En segundo lugar, el nivel promedio de capital humano aparece teniendo un impacto sobre la evolución de la productividad total de los factores. Por consiguiente, una razón para el bajo desempeño de la economía en términos de crecimiento per capita puede ser atribuida a la base de capital humano pobremente desarrollada en Guatemala que está muy rezagada del promedio latinoamericano. Los resultados empíricos en este estudio tienen algunas implicaciones de política. En particular, acentúan la necesidad en Guatemala de adicionar esfuerzos para aumentar su nivel de capital humano.

El promedio de años de escolaridad es una forma incompleta para medir el capital humano. Además, hay numerosos beneficios no monetarios de la educación y existe la posibilidad de que haya una masa crítica en donde la educación pueda tener un efecto más amplio. Por lo tanto, la contribución del capital humano podría estar subestimada en su forma cuantitativa. Teniendo en cuenta el bajo crecimiento de la productividad total de los factores en Guatemala, un hallazgo adicional es que la composición de la inversión aparece como un factor importante en el crecimiento de la productividad. Los resultados han sido considerados robustos dadas las restricciones de información y la estabilidad de los parámetros.

Appendix 1: Data

Table 5:

Adjustment Factors for Gross Enrollment Ratios and Average Years of Schooling within the Educational Levels

	Adjustment factors	Years of schooling	
	overall	1989	1998
Primary	0.805	3.819	4.093
Secondary	0.615	9.814	10.193
Tertiary	0.389	15.632	15.764

Source: Author's estimates and calculations from ENS (1989) and ENIGFAM (1998). Example: $1.022 \cdot 0.805 \approx 0.823$ is the adjusted primary gross enrollment ratio in 2000.

Table 6:

Educational Level of the Labor Force in Guatemala: Comparison of Census and Survey Data with Estimated Values

Year	Source	No school	Primary	Secondary	Tertiary
1950	SEGEPLAN (1978)	72.3 (NA)	24.9 (NA)	2.3 (NA)	0.5 (NA)
1964	SEGEPLAN (1978)	60.7 (62.6)	33.4 (33.3)	4.7 (3.7)	1.2 (0.6)
1973	SEGEPLAN (1978)	51.7 (53.5)	40.8 (41.0)	6.1 (4.6)	1.4 (1.2)
1981	CENSO (1981)	37.7 (45.8)	48.7 (44.7)	10.9 (7.8)	2.7 (2.3)
1989	ENS (1989)	38.9 (37.3)	47.7 (49.8)	11.4 (10.8)	2.1 (2.7)
1994	CENSO (1994)	35.4 (35.5)	47.8 (47.5)	14.1 (14.9)	2.7 (2.8)
1998	ENIGFAM (1998)	30.8 (31.8)	50.3 (49.1)	15.9 (16.2)	3.1 (3.2)
2000		NA (25.8)	NA (53.9)	NA (18.6)	NA (3.5)

Note: In percentage points. Estimated numbers are in parenthesis. Census and survey data may refer to the population aged 15-64.

Table 7:

Stationarity of the Time-Series

Variables	ADF test statistic	Result
lny	-2.29	non-stationary
lnk	-2.01	non-stationary
lnh	1.17	non-stationary
IM/I	-2.86*	stationary
Δ lny	-4.79**	stationary
Δ lnk	-4.26**	stationary
Δ lnh	-2.62*	stationary
Δ IM/I	-7.22**	stationary

** (*) Rejects the hypothesis of a unit root at the 1 (10) percent level assuming one lag and a constant in the test equation.

Table 8:

Breusch-Godfrey Serial Correlation LM Test

Residuals of	$n{\cdot}R^2$ statistic	Probability
Equation (4)	0.34*	0.85
Equation (5)	0.26*	0.88
Equation (10)	0.48*	0.79
Equation (11)	0.39*	0.82

* Indicates no serial correlation assuming two lags in the test equation.

Table 9:

Johansen Cointegration Test between Education and ln GDP per Worker

		Trace test			
		ln primary enrollment ratio	ln secondary enrollment ratio	ln tertiary enrollment ratio	ln average years of schooling
H_0	H_a	Statistical value			
r = 0	r ≥ 1	15.76*	13.81	17.86*	16.77*
r = 1	r ≥ 2	0.39	0.00	2.68	1.26

* Indicates one cointegrating equation at the 5 percent level assuming one lag in the test equation.

Table 10:

Description of the Data Sources

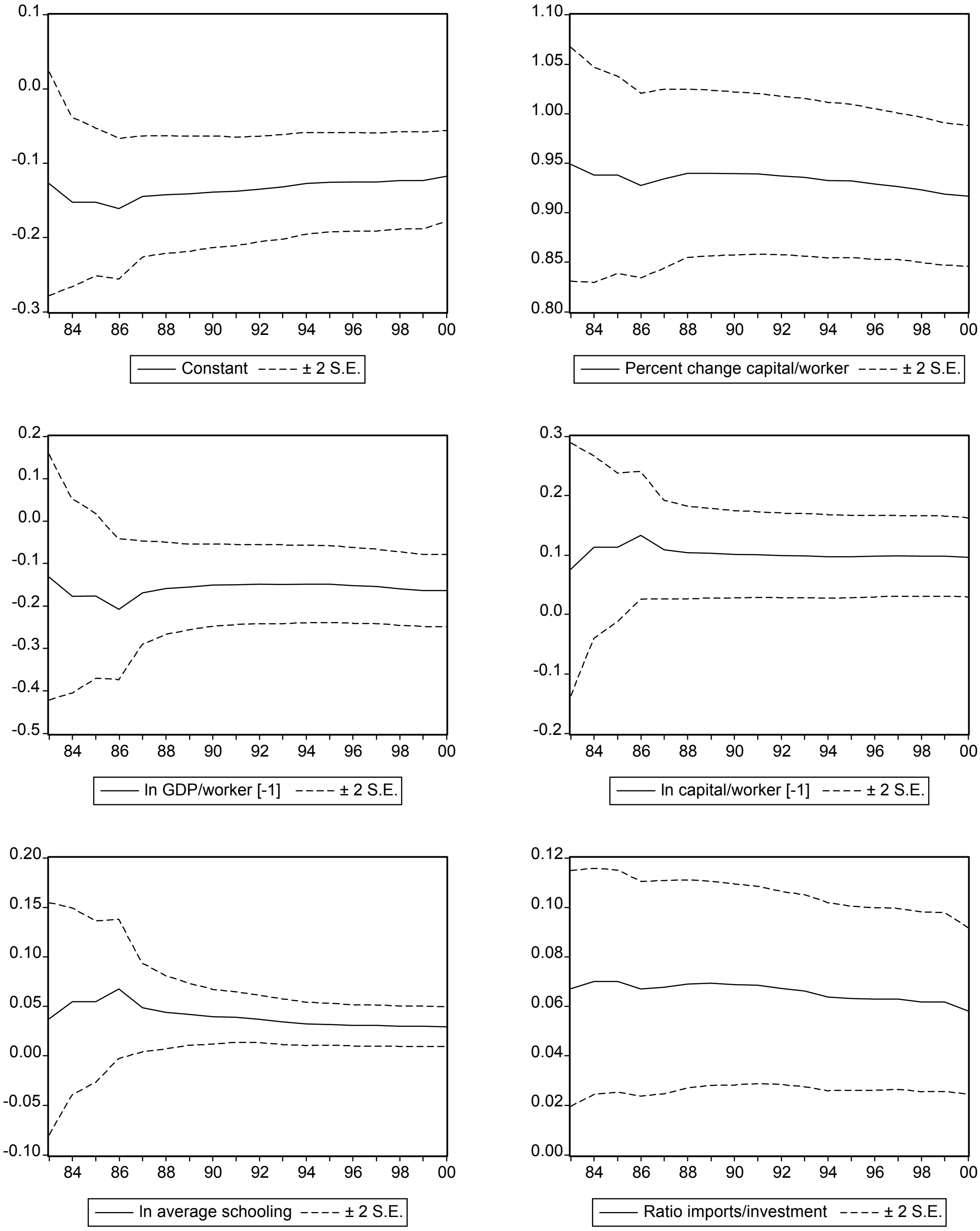
Variable		Source
Gross domestic product (GDP)	Y	Banco de Guatemala (2001), updated in 2002.
Capital stock	K	Perpetual inventory estimates, see text.
Gross fixed capital formation	I	Banco de Guatemala (2001), updated in 2002.
Imports of goods and services	IM	Banco de Guatemala (2001), updated in 2002.
Average years of schooling	h	Perpetual inventory estimates see text.
Population statistics	L15 L20	CEPAL and CELADE (2000).
Labor force	L	Derived from the number of private contributors to the Guatemalan Social Security System, see text. Data for 1960-2000 is taken from Banco de Guatemala (2001). Data for 1955-1959 was obtained directly from the Instituto Guatemalteco de Seguro Social (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 (2001). For 1991-2000 Ministerio de Educación (various years). 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 (2001). For 1988-1998 ratio of university students as reported in Global Info Group (1999) to the number of persons aged 20-24. For 1999-2000 enrollment ratios are proxied by that of *nivel diversificado* from the Ministerio de Educación (2001). Missing values were either interpolated or completed with information provided in Mitchell (1998), UNESCO (1966) and UNESCO (various).

Table 11: Time-Series

	Y	I	K	IM	IGSS	L	h
	thousand of 1958 Quetzales				workers		years
1950	722524	81670	1086913	104911	NA	947442	1.2492
1951	732525	79933	1112501	94472	NA	917001	1.2800
1952	747724	68940	1125815	84967	NA	886560	1.3149
1953	775292	67590	1137115	95080	NA	856118	1.3527
1954	789610	67039	1147298	105768	NA	825677	1.3927
1955	809107	90420	1180353	121559	198809	795236	1.4348
1956	882711	142481	1263816	153196	203572	814288	1.4770
1957	922494	154221	1354847	167210	236038	944152	1.5071
1958	976055	136315	1423419	164338	255548	1022192	1.5332
1959	1024223	125518	1477766	163049	255022	1020088	1.5596
1960	1049199	107812	1511690	165231	264100	1056400	1.5840
1961	1094267	113473	1549578	152933	269065	1076260	1.6116
1962	1132984	108678	1580778	164752	264884	1059536	1.6479
1963	1241064	128805	1630544	213401	274838	1099352	1.6881
1964	1298557	157790	1706807	234186	322289	1289156	1.7259
1965	1355156	166770	1788236	246955	345519	1382076	1.7653
1966	1429923	165886	1864710	251070	366946	1467784	1.8009
1967	1488609	184262	1955737	267088	367401	1469604	1.8454
1968	1619203	209430	2067380	277748	395808	1583232	1.8927
1969	1684343	212709	2176720	271794	446540	1786160	1.9394
1970	1792754	209627	2277512	293287	448276	1793104	1.9910
1971	1892832	227404	2391040	312071	442842	1771368	2.0607
1972	2031552	226112	2497600	294733	448378	1793512	2.1297
1973	2169378	251898	2624618	324212	468863	1875452	2.1960
1974	2307675	247192	2740579	370700	539792	2159168	2.2545
1975	2352750	270567	2874117	352057	520696	2082784	2.3185
1976	2526537	371393	3101804	457126	577920	2311680	2.3881
1977	2723844	405798	3352512	499819	708815	2835260	2.4548
1978	2859913	435653	3620540	521600	769045	3076180	2.5264
1979	2994650	413362	3852874	482783	756171	3024684	2.6089
1980	3106877	372592	4032823	441194	755542	3022168	2.6991
1981	3127560	401472	4232654	423061	591019	2364076	2.8058
1982	3016573	357665	4378686	334288	609144	2436576	2.8558
1983	2939604	258193	4417945	267857	583548	2334192	2.9067
1984	2953546	234936	4431984	287205	594936	2379744	2.9930
1985	2936062	220153	4430537	250278	631654	2526616	3.0710
1986	2940175	228558	4437568	213598	660444	2641776	3.1492
1987	3044395	266133	4481822	315784	678995	2715980	3.2079
1988	3162873	299826	4557558	327741	779560	3118240	3.2800
1989	3287594	318903	4648582	346883	788367	3153468	3.3613
1990	3389552	286160	4702313	344322	785753	3143012	3.4227
1991	3513627	296816	4764013	369249	786903	3147612	3.4700
1992	3683616	385212	4911025	505961	795708	3182832	3.5277
1993	3828260	411831	5077305	527335	823239	3292956	3.5855
1994	3982682	401038	5224477	553498	830324	3321296	3.6851
1995	4179767	435901	5399154	595513	855596	3422384	3.7500
1996	4303395	427259	5556456	554652	852243	3408972	3.7899
1997	4491199	523411	5802044	662824	844407	3377628	3.8498
1998	4715468	614623	6126565	825223	887228	3548912	3.9304
1999	4936878	650313	6470550	831098	893126	3572504	4.1021
2000	5059746	596681	6743703	839063	908122	3632488	4.3827
2001p	5249159	673816	7080334	891744	NA	NA	NA

Figure 3:

Recursive Coefficients – Equation (10)



Note: In recursive least squares equation (10) is estimated repeatedly in order to assess the parameter stability, using ever larger subsets of the data.

Appendix 2: Empirical Growth Studies for Guatemala

Using regression analysis, there are no studies that assess the direct impact of education on economic growth in Guatemala in a time-series context. Even the empirical evidence in a framework without human capital is limited. Some recent studies incorporate human capital as a skill-adjusted measure of labor inputs into the production function. Table 11 summarizes the results.

Table 12:
Comparison of Production Function Estimates for Guatemala

Author	Period	Production function	α	Method
World Bank (1996)	50-94	$Y_t = A \cdot K_t^{\alpha} \cdot L_t^{(1-\alpha)}$	0.63	First differences
Prera (1999)	65-96	$Y_t = A \cdot K_t \cdot^{\alpha} L_t^{(1-\alpha)}$	0.42^{+}	Level
Senhadji (2000)	60-94	$Y_t = A \cdot K_t^{\alpha} \cdot (L_t \cdot h_t)^{(1-\alpha)}$	0.73	First differences
			0.75	Level
Morán and Valle (2001)	76-99	$Y_t = A \cdot K_t \cdot^{\alpha} L_t^{(1-\alpha)}$	0.28^{+}	Level
		$Y_t = A \cdot (K_t z_t)^{\alpha} \cdot (L_t h_t)^{(1-\alpha)}$	0.09^{+}	Level

$^{+}$ Indicates low statistical significance.

Prera (1999) and the World Bank (1996:3) came up with rough capital share estimates of about 0.4 and 0.6 while estimating a standard Cobb-Douglas production function. Both studies find a moderate while positive contribution of total factor productivity to economic growth. While the World Bank neither provides a detailed methodology nor its data sources, the study from Prera faces several constraints regarding these issues. Particularly the fact that he ignores the existence of unit roots within the time-series context and the low significance of some of the estimated parameters places doubt on the reliability of the results.

Morán and Valle (2001) face the same problems while estimating a Cobb-Douglas production function for Guatemala. In addition, because of the relative short time period their parameter estimates must be considered carefully. In their estimate, both capital and labor inputs are quality-adjusted. Labor quality is derived from wage differentials of different levels of education. Their calculations suggest that labor quality has not increased much during the last decades which is in line with the findings of most studies that productivity growth in Guatemala has been low, but contradicts the fact of increased educational attainment. Unfortunately, the data corresponds only to the economically active population of the Guatemalan Social Security System (IGSS) and may therefore be a poor proxy for the human capital component of labor quality in Guatemala.

Senhadji (2000) estimate production functions for a sample of countries using different econometric techniques and takes into account the potential non-stationarity in the data. His calculation of the capital share is approximately 0.7 for Guatemala. In comparison to the Morán and Valle study, the human capital variable does not enter separately into the production function but as a skill-adjusted measure of labor inputs. However, the study relies on data compiled by Collins and Bosworth (1996) which are not explicit as to how they derived annual estimates of their human capital stock. In order to construct a time-series on the Barro and Lee data set which is available only at five-year intervals, they may have simply used linear interpolation to derive annual estimates of the human capital index.

Although the results differ considerably, studies that report significant regression results partially suggest that the capital share of income is rather high in the case of Guatemala. This finding is in agreement with many empirical studies which often report higher capital shares for developing countries. However, Collins and Bosworth (1996:155) argue that it could be a mistake to attribute the higher share to the greater importance of capital for economic growth and the lesser importance of human resources. Higher capital shares could be a symptom of severe market frictions due to weak competition and a substantial role of monopoly profits.

Some growth accounting studies for Guatemala also exist. Results often differ considerably and no firm conclusions can be drawn. The main discrepancies seem to stem from the assumed or estimated factor shares in the growth accounting exercise, as well as from data issues and distinct time periods. In general, the few studies that report results for Guatemala find that the role of technical progress was moderate (with the exception of Bailén 2001:87, see for example Bosworth et al. 1996:116, Edwards 2000:55, Gregorio 1992:68, Nehru and Dhareshwar 1994:32 and World Bank 1996:3).

Particularly interesting is the work of Sakellariou (1995) who uses the Lucas (1988) model of endogenous growth to test for external effects of education on wage differentials while analyzing microdata from the *Encuesta Nacional Socio-Demográfica* from 1989. He first estimates a wage equation and tries to filter out the internal effects of education. Then, to isolate external effects, Sakellariou regresses the resulting wage premiums in industry on average human capital as well as on control variables. Unfortunately, the study suffers from a limited number of industry categories and human capital variables. Consequently, the regressions turn out to be statistically insignificant. Stronger conclusions cannot be drawn. However, Sakellariou goes as far as finding that the analysis does not reject the hypothesis that external effects of human capital investment could be present in Guatemala.

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