Growth Accounting for Mozambique (1980-2004)

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Abstracto (Português)

Este papel investiga a trajectória do crescimento económico em Moçambique desde 1980 e particularmente desde o fim da guerra civil em 1992. Concentrando-se nos determinantes «próximos» deste crescimento, contra os determinantes mais «profundos», aplica-se um exercício de decomposição de crescimento na tradição do Solow (1957). Seguindo uma metodologia logarítmica transcendental (*translog*), uma contribuição frutuosa deste papel inclui a construção cautelosa de series consistentes de dados abordando o "stock" de capital privado e público bem como o "stock" do capital humano desagregado entre categorias de níveis diferentes de educação. Os resultados indicam que o ritmo rápido de crescimento pós-guerra se deve em grande parte à acumulação de capital e aos sucessos em melhorar o nível de educação da força de trabalho – uma prioridade do governo logo após a Independência até agora. Olhando ao longo prazo, embora o crescimento da produtividade total de factores tenha sido robusto desde 1992, ainda não há evidência nítida que este represente a construção duma base firma para sustentar altas taxas de crescimento económico no futuro.

Abstract (English)

This paper reviews the trajectory of economic growth in Mozambique since 1980, particularly since the end of civil war in 1992. Focussing only on the 'proximate' rather than the ´deep' determinants of growth, we undertake a growth accounting exercise in the tradition of Solow (1957). Employing a trans-logarithmic methodology, a useful contribution of this paper is the careful construction of consistent time series data covering private and public capital stocks as well as human capital stocks sub-divided into education-based categories. The results indicate that rapid growth since the end of the civil war in 1992 has been mainly achieved through capital accumulation and concrete improvements in the level of education of the working population, a governmental priority since Independence. Looking at the period as a whole (1980-2004), although total factor productivity (TFP) growth has been robust since 1992 it is as yet unclear whether this represents a firm base to support high rates of economic growth into the future.

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1. INTRODUCTION

This paper undertakes the purportedly mundane task of accounting for the trajectory of economic growth in Mozambique since 1980, focussing more closely on the post-civil war period since 1992. This is not an attempt to isolate and quantify the 'deep' determinants of growth during the period; rather, we focus on the 'proximate' determinants that can be identified through a growth accounting exercise. In particular we investigate the contribution of education to the improvement of human capital inputs in production. However, given the lack of consistent data and the considerable structural changes that have occurred, not least associated with the transition from a conflict to a post-conflict economy, this exercise demands careful estimation of the necessary time series data. As such, the minutiae of the growth accounting methodology are of considerable importance.

Section 2 provides a brief outline of the general theory of growth accounting followed by a sketch of the salient features of economic growth in Mozambique since 1980, including the results of previous growth accounting studies. Sections 4 through 6 give an in-depth treatment of the methodology and the construction of the underlying capital and human capital series. Section 7 presents and analyses the results while section 8 concludes.

In summary, we compare results using a transcendental logarithmic (translog.) and a standard Cobb-Douglas growth accounting procedure. In each case we find that improvements in education have made a very strong contribution to growth since 1980, particularly in the post-war period. There also is evidence of robust recovery in total factor productivity (TFP) since the civil war; however, it is not yet evident that such growth represents the emergence of a sustainable basis for future economic growth rather than being largely a phenomenon of post-war recovery.

2. GROWTH ACCOUNTING IN THEORY

The central idea behind growth accounting exercises is to explore the determinants of observed economic growth based on an aggregate production function. Following neo-classical theory, an aggregate production function combines factor inputs with some measure of the level of technology or technical know-how in production. Economic growth can be explained either by changes in factor inputs, such as increases in the stock of capital, or by changes in the technology of production. Alternative growth accounting approaches represent different attempts to articulate theoretically and/or apply empirically this fundamental idea.

The most simple, primal growth accounting models are based on work in the tradition of Solow (1957). Aggregate output (*Y*) is expressed as a function of the level of technology (*A*) and factor inputs of capital (*K*) and labour (*L*):

$$Y = F(A, K, L) \quad (1)$$

When differentiated with respect to time and further manipulated this gives:

$$\Delta Y = \sigma_A(\Delta A) + \sigma_K(\Delta K) + \sigma_L(\Delta L) \quad (2)$$

where σ_i represents the partial elasticity of the i^{th} variable with respect to output, given by the multiple of its marginal product with the inverse of its average product.[1] In addition, if we assume technology is Hicks-neutral in the sense that changes in technology affect labour and capital in equal measure, and that the factor marginal products are equivalent to factor prices, then from (2) we can derive the standard conceptual framework for growth accounting also used in empirical estimation:

$$\Delta Y = \Delta A + s_K \Delta K + s_L \Delta L \quad (3)$$

where s_i represents the share of factor *i* in total product. This allows us to express the change in *A* as a simple residual (the "Solow residual" measuring changes in total factor productivity, TFP) once movements in *K* and *L* and their respective factor shares are accounted.

The limitations of this approach to understanding growth have been noted repeatedly. In particular, the existence of a residual may be little more than a measure of our 'ignorance' (Abramovitz, 1956) as it is a function of those influences on growth not captured by the factor input measures such as exogenous shocks, macroeconomic stability, the institutional or policy environment as well as variations in the aggregate level of technology in production. For this reason meaningful interpretation of the size and movements in the residual often is not possible without further analysis.

[1] For example in the case of aggregate fixed capital: $\sigma_K = F_K \cdot (Y / K)^{-1}$

Despite these limitations, the growth accounting approach has been applied and elaborated in numerous ways.[2] Substantial effort has focused on improving the quality of the estimates of labour and capital and how they enter the production function. Studies have shown that the size of residual TFP growth may fall once we account for the quality or productivity of factor inputs rather than simply their raw amounts. To put it another way, including quality-adjusted factor inputs can indicate that accumulation of these (quality-adjusted) factors has played a more important role in observed growth than otherwise estimated. This has been clearly articulated and proven for growth in various East Asian countries by Young (1994); our objective in this paper is therefore to undertake a very careful growth accounting analysis for Mozambique, sensitive to quality improvements in factor stocks, particularly labour.

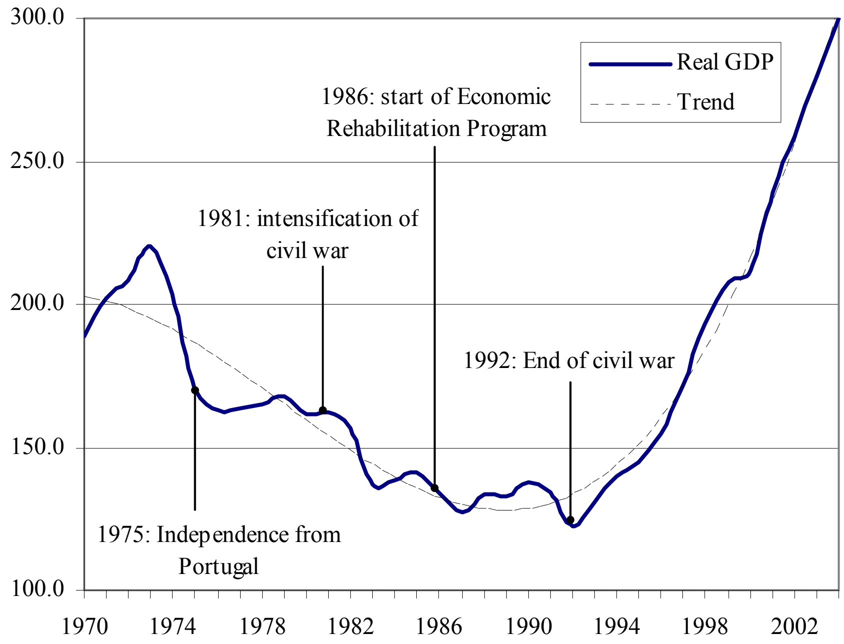
3. MOZAMBICAN GROWTH IN PERSPECTIVE

Before passing directly to the methodology employed in this paper, a few comments should be made about the trajectory of economic growth in Mozambique since Independence in 1975. This period has been marked by extreme changes not only due to the prolonged civil war which ended in 1992, but also due to the attempted transition to socialist central planning followed by market liberalisation, as well as rapid post-war economic growth.

Figure 1 shows changes in real GDP since 1970 with key historical events highlighted. It is evident that from 1973 the economy registered almost 20 years of secular decline, equivalent to an overall contraction of 45% in real output from 1973-1992 or an annual average real growth rate of around -3%. The 1992-2004 period, however, has seen an impressive recovery such that by 2001 real output was approximately equal to that of 1973, and by 2004 already 36% superior to the 1973 estimate. This in itself suggests the post-war period might be something more than *purely* a "recovery" phenomenon.

[2] See Barro (1998) for discussion of growth accounting variants and CBO (1994) for a survey of exogenous and endogenous growth theory. It should be noted that endogenous growth theories, in the tradition of Roemer (1986), make a strong departure from the neo-classical framework. They start with the proposition that technical change must be explained within the framework of the production model. Production is seen to be *potentially* subject to non-decreasing returns to factor inputs; in other words, certain forms of factor accumulation are permitted to generate positive spill-overs. These theories thus aim to discard (or internalise) the exogenously determined TFP term (A).

Figure 1: Mozambique real GDP 1970-2004, in billions of Metical at constant 1980 prices (source: author's calculations and INE, 1991-2004 GDP series)



A number of studies have analysed the determinants of Mozambican growth, particularly in the post-war era.[3] As might be expected, these suggest a wide range of plausible factors including peace and political stability, enhanced macroeconomic stability, the achievement of institutional market-based reforms (e.g. privatisation), foreign direct investment in a small number of large industrial projects (the so-called "mega-projects") and donor-supported public investments in infrastructure and provision of social services. While these studies are of general analytical interest, this paper does not attempt the Herculean task of providing a comprehensive review of the Mozambican growth experience in historical detail. Thus we focus here only on results directly relevant to this paper, namely growth accounting exercises applied to Mozambique.

IMF (2005), also presented in World Bank (2005), employ a rudimentary Cobb-Douglas specification equivalent to equation (3) holding labour and capital shares constant at 60% and 40% respectively. Due to a lack of employment information (IMF 2005: 14) the labour force is proxied by population data such that human capital quality is not taken into account. The results covering the period 1981-2004, partially reproduced in Table 1, indicate that a large proportion of growth throughout this

[3] For example see IMF (2005), World Bank (2005), República de Moçambique (2005b), Tarp et al. (2002), Castel-Branco (2002), Arndt et al. (2000), Ardeni (1999).

period and in discrete sub-periods derives from the (unexplained) contribution of changes in TFP. They find, for example, that TFP growth accounts for 40.1% of output growth in 1981-2004 and 53.8% in the post-war era. Interestingly, both TFP growth and output growth are reported as being on average *positive* during the period 1985-1992 (respectively at 1.1% and 3.2% on average per annum) despite the intensification of the civil war in 1985 and severe droughts in 1986-87 and 1991-92, the latter threatening over 3 million Mozambicans with starvation (IMF, 2001: 27).[4]

Benito-Spinetto and Moll (2005), in a background paper to World Bank (2005), present a similar model including a labour force term adjusted for educational quality entered into a Cobb-Douglas specification as per equation (6) (see section 4). For the relatively short period analysed, mid-1997 to end 2002, the improvement in labour force quality accounts for 7% of growth whilst pure stocks of labour and capital account for 15% and 37% of growth respectively, leaving around 40% of growth in the residual. Compared to the previous study, the inclusion of a labour quality adjustment thus moderately reduces the size of the residual.

Sulemane (2001) undertakes a growth accounting exercise for a much longer period, 1960-1996, which covers the phase of colonial economic expansion as well as post-Independence economic decline. The methodology employed is broadly similar to World Bank (2005) although in this case the factor shares are not assumed but rather estimated from production function regressions giving a much higher share (approximately 75%) to capital. The author understands this as a reflection of the relatively low endowment of capital across the economy increasing the rental rate of fixed capital. In keeping with other studies, the results also attribute large portions of output changes to changes in TFP, both for different sub-periods and for the period as a whole. In the phase of pre-Independence growth, TFP is estimated to have grown at 4.4% per annum on average, explaining 84.5% of output growth. Declines in TFP explain over 100% of the economic contraction from 1974-86. Of import, however, is that labour force accumulation (unadjusted for quality) consistently explains less than

[4] Note that INE only publish a consistent real GDP series from 1991. Thus, analysts must make their own estimates for any backwards extensions to this series (see section 4.1).

1% of changes in output; as such we can expect that variations in labour force productivity are subsumed within the TFP residual.[5]

Finally, a number of cross-country studies also estimate the contributions of TFP and factor accumulation to real growth in Mozambique. Ndulu and O'Connell (2000, 2003, 2004) employ a growth accounting approach similar to equation (6) (see below) across a large set of African countries. Incorporating a labour force adjustment for educational attainment based on average school years (2003: 2-3, 12) they find changes in TFP explain the lion's share (over 50%) of growth in all 5 year episodes from 1960-2000 in Mozambique. For the final period estimated (1995-2000) TFP changes explain 75.8% of output growth against only 2.5% for education per worker. However, for the entire 40 year period they calculate education has contributed 28% to output change and the residual 52% (see table 1 below). In contrast, using a very similar specification and methodology but *without* labour stock quality-adjustments, Tahari et al. (2005) finds that TFP movements explain only 8.3% of growth from 1960-2002 against 64% for capital accumulation and the rest labour.

Table 1: Summary of selected results from growth accounting studies for Mozambique

		% contribution to ΔY in period		
Study	Period	Capital	Labour*	TFP
Tahari et al. (2005)	1960-2002	63.9	27.8	8.3
Ndulu & O'Connell (2003) **	1960-2000	20.0	28.0	52.0
Sulemane (2001)	1974-1986	-3.6	0.0	103.6
Sulemane (2001)	1980-1996	35.1	0.0	64.9
IMF (2005) ***	1981-2004	60.9	-	39.1
Sulemane (2001)	1987-1996	45.6	0.1	54.4
Ndulu & O'Connell (2003) **	1995-2000	21.7	2.5	75.8
IMF (2005) ***	1996-2004	50.6	-	49.4
Benito-Spinetto & Moll (2005)	1997-2002	37.2	22.1	40.7
Average		*36.8*	*11.5*	*51.7*

Notes:
* depending on the study this term may be adjusted for human capital quality; in Ndulu & O'Connell it represents a pure education index
** Ndulu & O'Connell (2003) express Y and capital in per-worker terms
*** IMF (2005) do not decompose factor accumulation into labour and capital components

In sum, it appears that results from growth accounting exercises are sensitive to the underlying data and methodology, including assumptions concerning factor shares and depreciation rates. While the majority of previous studies appear to find a large

[5] Indeed, the author goes on to regress the (annual) TFP residual estimates against a number of explanatory variables including a human capital measure (2001: 69); however for the period under analysis import capacity constraints represent the most important single explanation of TFP changes.

residual in Mozambican growth, regardless of the period, there is weak evidence that once human capital quality is included this residual diminishes moderately. Most studies estimate that the contribution of capital accumulation to growth has been strong throughout the pre- and post-Independence periods. To a limited extent this accords with Tahari et al.'s (2005) conclusion concerning the drivers of sub-Saharan African growth since 1960 – that growth paths within the region have been driven primarily by factor accumulation*, not* TFP improvements.

The growth accounting analysis undertaken in the remaining sections represents an attempt to build-on the above studies not only by applying a more flexible methodology, but also by making a careful estimation of factor stocks adjusted for educational quality and war-related damage. It should be stressed, however, that this represents only a first step towards a more accurate and deeper understanding of growth determinants between 1980 and 2004. The relative contributions of technology, factor accumulation and factor productivity improvements do not in themselves explain growth. Rather, they merely help to quantify the proximate determinants of growth and indicate those aspects which merit further analysis.

4. METHODOLOGY

Given substantial improvements in the educational profile of the population in Mozambique since Independence (see section 5), we adopt a methodology sensitive to changes in the quality of labour inputs. The framework we use follows Young's (1994) implementation of a translog production function and associated translog factor input indices. It can be shown that based on a generic translog function of type:

$$F(X_i) = \exp\left\{ \alpha_0 + \sum_i \alpha_i \ln(X_i) + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln(X_i)\ln(X_j) \right\} \quad \ldots \; \forall \; i = j, i \neq j \quad (4)$$

where X_i represents a vector of choice variables, changes in a translog production function between two discrete time periods with aggregate inputs K and H is given by:

$$\ln\left(\frac{Y_t}{Y_{t-1}}\right) = \bar{\theta}_K \ln\left(\frac{K_t}{K_{t-1}}\right) + \bar{\theta}_H \ln\left(\frac{H_t}{H_{t-1}}\right) + TFP_{t,t-1}$$
$$\text{where } \bar{\theta}_i = \frac{1}{2}(\theta_{i,t} + \theta_{i,t-1}) \quad (5)$$

in which the θ_i's represent the share of each input in total factor payments and the final term indicates the growth in a translog TFP measure representing the expected logarithmic growth in output between periods assuming all factor inputs remained constant (Young, 1994: 6).

A distinct advantage of this specification, compared to a rudimentary Cobb-Douglas formulation with constant factor shares, is that it imposes no constraints on variations in these factor shares over time. Moreover, the additive nature of equation (5) is highly flexible, permitting the development of disaggregated factor indices based on the same specification and, consequently, measurement of the individual contribution of these sub-factor components to aggregate output growth. This study makes explicit use of this feature by disaggregating labour into six education-location sub-categories and fixed capital into private and public sector components. Finally, it should be emphasised that our implementation of this framework involves the estimation of values for all elements of (5), treating TFP growth as the residual. We therefore do not employ regression-based techniques although these often are used in growth accounting studies particularly when cross-country comparisons are made.[6]

In order to verify the results from the translog approach, we also employ a standard Cobb-Douglas growth accounting framework both with and without a human capital adjustment. The Cobb-Douglas framework can be expressed in the form of equation (3) in which the factor shares sum to unity, ensuring that production is homogenous of degree one in inputs of capital and labour. The human capital-augmented form of equation (3) used in this paper derives from a production function of type:

$$Y = AK^{\alpha}(hL)^{(1-\alpha)} \qquad (6)$$

in which the labour term is adjusted directly by a human capital index h; this approach is described further in section 5.2.

The period chosen for analysis is 1980-2004, the starting point being the first date for which we have education matriculation figures. This date also coincides with the initiation of a new and more hostile phase in the civil war, as well as extensive attempts at socialist central planning. It also is important that a relatively long period

[6] The relative advantages of regression-based vs. arithmetic growth accounting approaches are not discussed here.

is analysed to allow lagged impacts from the accumulation of factor inputs to have their due effect.

5. MEASURING HUMAN CAPITAL

As noted above, careful growth accounting analysis requires the construction of robust factor input measures. This section describes the methods used to estimate changes in human capital stocks since 1980. The intention is to measure both labour force quantity *and* quality in order to capture the improvements in the educational profile of the population from an extremely low base. In other studies of this kind for other countries, the required data often is extracted from census or labour force surveys. However, as the Mozambican information base is much weaker in comparison to many middle-income and developed countries the estimation methods must be adapted to the available information. For this reason the methodology developed here is presented in detail.

The relevance of including an adjustment for human capital quality in Mozambique is evident from a brief survey of the expansion of the education system since Independence. It has been widely noted that education of the indigenous population was neglected during the colonial period such that on the eve of Independence there was no higher education institution open to black Mozambicans and approximately 93% of the population was illiterate (UNDP, 2000; UNESCO, 2000; MPF and MINED, 2003). Historically, education of the indigenous population had the minimal objective of enabling a basic adaptation to or assimilation of colonial language and culture.[7] Even with the abolition of the *indigenato* in 1961, which opened-up some expansion of primary schooling, secondary-level or higher education essentially was prohibited in order to avoid the establishment of an educated elite cadre with potential to oppose the *colono* (colonial power). As a result, the post-Independence government of FRELIMO (Frente de Libertação de Moçambique) viewed as essential the expansion of education and particularly basic literacy programs.[8] The first years of

[7] From 1956 the only education available to black Mozambicans was entitled "ensino de adaptação" (Cruz e Silva, 1998) and consisted only of very rudimentary literacy and numeracy. For further detail on the history of education in Mozambique see UNDP (2000) and Buendía Gómez (1999)

[8] This was adopted as a priority under the first FRELIMO congress held in Dar-es-Salaam in 1962. For example, *Programa* 17 of FRELIMO (1962) states the objective of "Liquidação da educação e cultura colonialistas e imperialistas. Reforma do ensino em vigor; combate enérgico e rápido ao analfabetismo."

Independence saw a massive expansion of both these literacy programmes and primary schooling (UNDP, 2000; Buendía Gómez, 1999). Although the intensification of civil war in the early 1980s significantly constrained the success of this expansion, the civil war period nonetheless witnessed considerable advances in the educational profile of the population given the extremely low starting point. The movement away from socialist central planning from 1986 also allowed the development of private education institutions which, more recently, have played an important role in the expansion of education at higher levels.

In this paper two measures of human capital are employed. First, in keeping with the principal growth accounting methodology we develop a translog human capital index based on various education-based sub-categories. Second, and for the purpose of comparison, we estimate a more standard index based on the average wage rate.

5.1. Translog index of human capital

Following Young (1994), a translog index of human capital can be constructed by disaggregating the gross stock of economically active human capital, (the number of workers), into different categories. Thus, defining *H* as the overall measure of human capital populated by various categories of economically active skilled, (*S*), and unskilled workers, (*U*), the general formula for changes in a translog index of *H* between two discrete periods is given by:

$$\ln\left(\frac{H_t}{H_{t-1}}\right) = \bar{\theta}_S \ln\left(\frac{S_t}{S_{t-1}}\right) + \bar{\theta}_U \ln\left(\frac{U_t}{U_{t-1}}\right) \quad \text{where } \bar{\theta}_i = \frac{1}{2}(\theta_{i,t} + \theta_{i,t-1}) \qquad (7)$$

in which the θ_i's represent the share of each sub-input in total payments to *H*, and where the sub-indices, *S* and *U*, are constructed in the same fashion. As mentioned previously, the advantage of this additive construction is that it permits the measurement of the individual contribution of each sub-factor to aggregate growth.

The following sections detail the distribution of the working age population, adults aged between 15-64 years, denoted as *W,* into different categories of skilled and unskilled workers. The skilled categories include both rural and urban categories of workers with a primary school (*EP*) education, and workers with a secondary school qualification or above (*ES*). Unskilled workers (*UN*) also are divided into rural and urban categories. In total this allows us to estimate six sub-categories for *H*. Thus, ignoring the rural and urban divisions within each category, the estimation in fact involves partitioning *W* into the following elements where *act* and *inact* subscripts refer to economically active and inactive groups respectively, (time subscripts are ignored):

$$W = EP_{act} + EP_{inact} + ES_{act} + ES_{inact} + UN_{act} + UN_{inact} \quad (8)$$

The methodology employed to populate these sub-categories relies principally on annual student matriculation figures at the primary and secondary levels. This data can be used to construct perpetual inventory-type stocks similar to those used in fixed capital stock estimation (see section 6). These methods are commonly found in the literature for both single- and cross-country studies, often employing gross enrolment rates (e.g. Barro and Lee, 1993; Nehru et al., 1995; Ahuja and Filmer, 1995). It should be noted, however, that such methods generally either require long time series data on repeat- and drop-out rates, or must assume stability in the efficiency of the education system over time. For Mozambique although we do not have such consistent time series data we also cannot assume stability in efficiency rates given the expansion of the education system during the period. As a result, the methodology we develop here is adapted to the available data and explicitly adjusts for improvements in efficiency.

Three caveats can be mentioned at this stage. First, while it is recognised that a fraction of students within the education system are economically active, for ease of presentation we do not explicitly take them into account. Second, we recognise that a substantial proportion of students who exit the educational system with a qualification do not fall within the working-age population but will only enter this cohort with a lag. We also do not attempt to make adjustments for such lags, assuming that on aggregate and over time these errors are not material. Third, while the following discussion covers economically active *and* inactive stocks, it should be emphasised that in the growth accounting calculations we only include economically active individuals.

The starting point for our estimation requires annual estimates of the working-age population, *W*. These can be built from various sources including those of INE as well as the IAF 2002/03 household survey.[9] In this case we take official INE values in 1980, 1990 and 1997 as well as the IAF 2002/03 figure as fixed points in the *W* series. We then estimate a smooth set of growth rates consistent with these fixed points and apply these growth rates from the first fixed point (1980) through to 2004 to give the final series.[10]

5.1.1. Primary school education

The first two categories of *S* are populated respectively by the urban and rural stocks of working age economically active individuals whose highest qualification is at a primary school level, referring to the final exam at the end of either of the two primary school cycles (Escola Primária cycles, EP1 and EP2). Using the available information on educational enrolment at this level, being the only consistent time series data obtainable, we thus wish to estimate the proportion of enrolled students who exit the education system having completed successfully either of the two EP qualifications in each year. We then estimate the proportion of this stock that is economically active divided between urban and rural areas, i.e.: $EP_{total} = EP_{act} + EP_{inact} = EP_{act,\ rural} + EP_{act,\ urban} + EP_{inact}$.

For this purpose, we employ transition matrices for the EP cycles that have been developed in Arndt and Muzima (2004). These give the proportion of students enrolled in each class who repeat the same class, move to the next class, or exit the system. However, as each row of the matrix sums to unity we do not know, *a priori,* the expected distribution of students across classes or the likelihood of a given matriculating student being located in each (non-zero) cell for the period. These probabilities, however, can be calculated by simulating the flow of students through the transition matrix.[11] As might be anticipated, assuming a constant number of entrants in the first class in each period this exercise quickly generates a stable distribution of students across classes after a small number of simulation-periods. This

[9] IAF stands for *Inquérito aos Agregados Familiares sobre o Orçamento Familiar* (Household Living Standards Measurement Survey) being a national survey undertaken first in 1996/97 (see MPD et al., 1998) and repeated in 2002/03 (see MPD et al., 2004).

[10] This approach is preferred as it avoids sharp changes in the growth rates which would occur using only growth rates determined by the fixed points. To calculate the smoothed growth rates we calculate the required annual (logarithmic) growth rates between each fixed point and apply a Lowess smoother (a non-parametric technique involving locally weighted regressions; see Cleveland, 1981) to this series.

[11] In other words, given a transition matrix, R, the distribution of students across classes at time t+1 will be given by $S_{t+1} = R'S_t + E$, where E is a column vector containing in the first cell the number of new entrants in the starting class with all other cells set to zero.

original transition matrix can then be applied to the simulated distribution to calculate the total "probability-position" for each non-zero cell in the original transition matrix. Employing this technique for the average (non-stationary matrix) estimated in Arndt and Muzima (2004) for 2001, table A.1 (annex A) gives the probability-position matrix for grades 1 through 10 (EP1, EP2 and ES1) based on 100 simulation-periods.

The original analytical objective can be framed as a probability problem – for a given cohort of EP students we require the combined probability of leaving the system with a qualification and entering the labour force. Breaking this problem into its constituent parts, the simple likelihood for all EP students of having an EP qualification can be proxied by the ratio of students in the EP2 cycle to the EP1 cycle, (itself a measure of the probability of transition from EP1 to EP2), adjusted for the probability of completing EP1 and then leaving the system. Ignoring time subscripts, this is given by ρ_1 (stated in percentage terms):

(9) $\rho_0 = \text{P(enter EP2)} \approx \text{EP2/EP1}$

(10) $\rho_1 = \text{P(having either EP1 or EP2)} \approx \text{P}[\rho_0 + \text{P(complete EP1 and exit)}]$

$= \rho_0 + 3.0$

in which the constant term of equation (10) is the probability of exit after EP1 derived from the position-probability matrix. The advantage of this formulation, rather than relying on the probabilities derived from the average transition matrix, is that ρ_0 is derived from annual data and thus allows ρ_1 to reflect improvements in scholastic inter-annual transition rates. It should be recognized, however, that the base data is not of a consistent quality due to differences in statistical coverage between years (as recognised by INE, 2005). As a result, we (Lowess) smooth the annual ρ_0 estimates to generate a less volatile trend.

The second probability, of exiting the education system given one has passed either of the two EP qualifications, also can be estimated from the position-probability matrix. This indicates that approximately 53.5% of all students holding an EP qualification exit the system in each academic year, of whom 27.8% then move to secondary school.

(11) $\rho_2 = \text{P(exit the system} \mid \rho_1)$

$\approx \text{P}[\text{ P(complete EP1 and exit} \mid \rho_1) + \text{P(exit EP2 – continue to ES} \mid \rho_1)]$

$\approx 19.2 + 34.36 - 14.9$

$= 38.6$

However, recognising that the constant values in (10) and (11) both are stationary – being based on the probability-position matrix for 2001 – we assume that these observed probabilities are the result of improvements in scholastic efficiency during the period. Assuming that these improvements can be proxied by changes in the ratio of EP2 to EP1 students, we create a moving adjustment factor, λ, for these constants based on movements in ρ_0 against the 2001 base year in each period such that: $\lambda_t = (\rho_{0,t} / \rho_{0,2001})^{0.25}$. Combining the above, the expected percentage of all EP students who exit the education system having completed at least one level of the EP scholastic cycle is approximated by (ignoring time subscripts):

(12) $\rho_3 = P(\text{completed and exit EP}) = (\rho_0 + 3\lambda) \cdot (\rho_2 \cdot \lambda)$

When applied to the number of enrolled students in both EP cycles and combined with a stock depreciation rate estimated constant at 1% per annum, equation (12) is sufficient to estimate EP_{total} once a base year or point in the series is known. In our case, we use the IAF 2002/03 data on the stock aged over 15 years of age who hold an EP qualification and no more and apply backwards to 1980. Interestingly the total EP stock estimate for 1980 shows that 8% of the working age population had achieved a primary-level qualification and exited the school system. This is consistent with a small improvement in aggregate education levels since Independence (see above) and indicates these stock estimates can be taken as broadly robust.

The IAF 2002/03 data also indicates the proportion of the 'EP stock' that is actively engaged in the labour force (economically active). Thus, assuming this percentage has remained stable, and without any indicators to the contrary, we apply this constant to the total annual stock calculated above. This economically active EP stock (EP_{act}) is then split between rural and urban locations also based on the ratio given by the IAF 2002/03. We adjust this ratio, however, to take into account the greater destruction of rural infrastructure during the war years, as well as population dislocation from many rural locations. Thus, we conservatively estimate that the ratio of rural to urban economically active EP stock has improved at a rate of 1% per annum from 1980 to 2002.[12] A summary of these calculations is shown in Table A.2.

5.1.2. Secondary school education

A similar approach is used to estimate the stock of economically active individuals that have completed at least one level of secondary school (escola secondária, ES) or equivalent education (ES_{act}). This stock includes those with tertiary level education, which is not a material failing given the very low numbers of individuals in this category, being approximately 0.64% of the economically active population in 2002/03.

At this educational level, however, the estimation procedure is more complex. First, the secondary and tertiary education systems have witnessed very rapid expansion since 1980, despite the civil war. For example, according to official statistics (INE, 2005), in 1980 only 413 students were enrolled into the second cycle of ES compared to 21,350 by 2004. Second, compared to EP, the pattern of ES and tertiary education is characterized by greater intermittency, with many individuals following an irregular path through the system including substantial breaks between EP and ES and between ES and tertiary education. Third, detailed transition matrices encompassing the entire ES system (and the tertiary system) have not been estimated. Given these difficulties, a simplified methodology is adopted in which the estimated probability for all enrolled ES students of leaving the ES and tertiary systems with a qualification from at least one ES or tertiary level is estimated as a varying proportion of the known transition rate from ES2 to ES1; such that:

(13) $\rho_{4t} = P(\text{enter ES2}) \approx ES2/ES1$

(14) $\rho_{5t} = P(\text{completed and exit system})$

$$= \rho_{4t} \cdot P(\text{exit} \mid \rho_{4t})$$

$$= \rho_{4t} \cdot \rho_{5t}$$

$$= \rho_{4t} \cdot [\rho_{5t+1} \cdot (\rho_{4t} / \beta)]$$

Once again, due to noise in the ρ_4 estimates we apply a Lowess smoothing procedure to generate a less volatile trend. Note the final square-bracketed term of (14) represents the probability of exiting the scholastic system given a completed ES or

[12] Thus working backwards from 2002, the ratio at time t is given by $r_t = 0.99 * r_{t+1}$

tertiary qualification. This term is not fixed, but rather to capture improvements in the overall system is indexed against movements in $\rho_{4,t}$, with the constant term β being equal to $\rho_{4,t}$ at t=2002 (the base year). Finally, the 2004 starting value for ρ_5 is set to ensure that the 1980 stock of individuals in the 15-64 population with an ES qualification or above is equal to 117,000, being approximately 10 times the number of matriculating students in the 1980 ES1 cohort. This method gives a robust fit to the equivalent 1997 stock data with an error of only 0.8%. The results from this estimation procedure also are summarised in table A.2.

As for the primary education category, we apply the participation rate as well as the rural-urban split given by the IAF 2002/03 data to estimate the rural and urban categories of ES_{act}. We fix the participation rate as being constant (at 76%) and allow the rural-urban split to move slowly as described in the previous section.

5.1.3. Unskilled labour

The final, residual categories of *H* which are used to construct the *U* index refer to the economically active stock without any educational qualifications. Due to the very low level of investment in education during the colonial period, this category has continued to represent the majority of the population since Independence. Estimation of this stock is relatively simple given the above calculations which give us the stock of economically active and economically inactive individuals by educational status. The economically active unskilled labour stock, UN_{act}, is thus calculated as follows:

(15) $$W_{inact} = 8.5\% \cdot W + EP_{inact} + ES_{inact}$$

(16) $$W_{act} = W - W_{inact}$$

(17) $$UN_{act} = W_{act} - (EP_{act} + ES_{act})$$

Note W_{inact} is the estimate of the economically inactive working age population, estimated as the inactive educational stocks plus a fixed constant of *W*, (set to represent unskilled domestic labour that does not contribute to GDP). Lastly, the rural/urban split of UN_{act} is constructed as in the preceding section also based on IAF 2002/03 data.

5.1.4. Sub-factor shares

As per the growth accounting methodology presented above we need to estimate the labour sub-category factor shares which operate as weights on the first difference logarithmic specification. Following the literature these shares should represent the relative contribution of each sub-category to total economic services provided by labour according to average hourly wage rates and average number of hours worked for each category based on labour force survey or census data (Bureau of Labor Statistics, 1993; Young, 1994; Schwerdt and Turunen, 2006). Within this framework it also is common to specify (micro) Mincer-type wage regressions to estimate the wage increment associated with different levels of education.[13]

In the case of Mozambique, robust data of this sort is not available on a time series basis. We can, however, use household survey consumption data to derive comparable estimates. Indeed, given the existence of numerous non-salary forms of income as well as diverse earnings sources, consumption data is generally seen to provide a more reliable guide to well-being in developing countries and undertake inter-household welfare comparisons (Ravallion, 1992; MPF et al., 1998). We further assume, and in the absence of labour-intensity data, that consumption is an adequate proxy for both wages and hours-worked; in other words consumption is a final outcome variable being, *inter alia,* a function of hours worked and income earned. Stating this formally, we postulate that the productivity increment due to education can be estimated from a Mincerian-type regression of the form:

$$c_i = \alpha_0 + \alpha_1 \left(edu_i \right) + \Phi X_i + \varepsilon_i \tag{18}$$

in which c_i is the logarithm of consumption of the i^{th} individual, *edu* is a measure of her education, X a vector of control variables including age and ε the residual error term.

Estimating (18) from household-level survey data generates a number of empirical complications, largely as the consumption indicator is calculated for the entire household rather than each individual. One way of dealing with this problem is to estimate the regression at the household level taking as the education indicator the highest education-level achieved by any household member and stating the dependent variable either as consumption per household member or total household consumption. This approach is likely to be biased when there are a large number of

[13] See Pritchett (2004) and Sianesi and Van Reenen (2000) for a more detailed discussion of returns to education and difficulties associated with the application of education measures in macro-growth analysis.

economically active persons in the household and/or a large number of individuals with similar levels of education. The second approach is to organise the household data on an individual basis, restricting the analysis only to economically active individuals. This approach involves modifying the dependent variable to measure consumption per economically active individual, thus in some way removing the effect of pure dependents. Of course, the bias in this approach is likely to run in the opposite direction and would be higher the more varied the educational attainments *and* relative contributions to group consumption of members of the same household.

To measure and correct for the size of the bias from each of these two approaches is not within the scope of this paper. Rather, using the most recent IAF 2002/03 data we estimate the coefficients derived from both approaches. As shown below in table 2, and in more detail in table A.3, the results are extremely comparable and have reasonable predictive accuracy at between 38% and 34% (R-squared) despite the disparity in the number of observations – 6,231 against 15,971 respectively for the two specifications. Without knowing the extent of the biases inherent in each approach our best predictor is a simple average of the coefficients from the two estimations. Interpreting the results, each education-location category is represented by a dummy variable in the empirical specification such that the (average) coefficient for each dummy gives the increment to the log of consumption above the level of consumption given by the intercept (which is equivalent to the consumption of the base category – rural workers with no education). These coefficients are controlled for the effects of household size, the number of dependents and the age of the individual. The results can be used to calculate average nominal consumption for each education-location level, also given in table 2 below. It should be highlighted that these education premia are comparable to results from similar regressions on the same survey data (following the household-level approach) estimated in Maximiano et al. (2005) and Fox et al. (2005).[14]

[14] Note that in Fox et al. (2005) the regression specification includes gender, industry and regional fixed effects. These are not included in the specifications used for this paper as the labour stock categories are not adjusted for these variables. In other words, we prefer to permit the estimated education coefficients to reflect the *average* effects associated with these variables. Note, however that when such effects are included in our specification the estimated coefficients track even more closely the results of Fox et al. (2005).

Table 2: Regression results and derived log, nominal and consumption ratios for each category of education and location; based on IAF 2002/03

	Regression results			Consumption		
	Household	Individual	Mean	Log	Nominal	Ratio*
None (rural)**	1.13	2.22	1.68	1.68	5.34	1.00
None (urban)	0.06	0.34	0.20	1.88	6.53	1.22
EP (urban)	0.75	0.87	0.81	2.48	11.97	2.24
EP (rural)	0.21	0.21	0.21	1.89	6.59	1.23
ES (urban)	1.56	1.62	1.59	3.27	26.24	4.91
ES (rural)	0.82	0.74	0.78	2.45	11.62	2.18

Notes:

* "Ratio" is based on nominal consumption with "None (rural)" as the base category.

** Regression results here represent the intercept, all other results give the increment.

With respect to the calculation of labour sub-category factor shares, it is trivial to show that only wage or consumption *premia*, (the ratio of the estimated wage in a given sub-category against a fixed base category), are required rather than average wage *levels*. Denoting s_i as the stock of labour in category i, w_i as the category's average wage and α_i as the wage ratio against a fixed base category, z, such that $\alpha_i = w_i / w_Z$, the factor shares, l_i, are given by:

$$l_i = \frac{s_i w_i}{\sum_i (s_i w_i)} = \frac{s_i w_Z \alpha_i}{w_Z \sum_i (s_i \alpha_i)} = \frac{s_i \alpha_i}{\sum_i (s_i \alpha_i)} \quad (19)$$

Thus, whilst from table 2 we use the consumption ratios as our estimates for α_i for 2002/03, we must concern ourselves with the stability of these premia over time. This is not easily resolved due to a shortage of similar surveys since our starting year. The IAF survey undertaken in 1996/97 represents the only viable comparator and would indicate that at least through to 2002 these premia have remained broadly stable. This is shown by the similarity in the estimated parameters from the wage and consumption regressions estimated in Fox et al. (2005: 29) for the two IAF surveys, Maximiano et al. (2005) for IAF 2002/03 and MPF et al. (1998) for IAF 1996/97.

In consequence, we assume these education-based premia have remained stable since 1980 – a conservative assumption given the extreme scarcity of educated human capital towards the beginning of the period. Although this assumption gives constant α_i's it does not generate constant sub-factor shares as changes in the distribution of human capital among the different stock categories ensure the factor shares move in accordance with the quality of the labour force.

5.2. An alternative human capital indicator

A more standard approach to measuring human capital, associated with a Cobb-Douglas methodology of type equation (6), can be estimated via a human capital quality index given by:

$$h = \sum_i p_i \alpha_i \tag{20}$$

where p_i is the proportion of the active labour force with education level i, weighted by a measure α_i of the level of education such as the wage premium or mean years of schooling. For ease of analysis we can use both the human capital stocks and the wage premia developed above to estimate h; however, it would be equally possible to apply wage or consumption coefficients from regressions based on household survey data as our α_i weights. For each period the resulting values for h are multiplied by the total active working population ($L = W_{act}$) to give our final index, Lh, summarised in table A.3.

6. MEASURING THE FIXED CAPITAL STOCK

For this paper we disaggregate the total fixed capital stock into its government and private sector components. This is worthwhile from the perspective of analysing the relative contributions of private and public sector investment to post-war growth, possibly related to destruction and rebuilding of public infrastructure. For this estimation we calculate separately the aggregate and the government fixed capital stocks for each year from 1980 to 2004. We then treat the private sector stock as the residual. As already noted, these two sub-categories of aggregate fixed capital can be inserted into the translog growth accounting equation in the same fashion as the human capital sub-indices.

Consistent with numerous other studies, real capital stocks can be estimated via a perpetual inventory method. This states that the stock of capital at time t, K_t, is given by adding real investment in the period, I_t, to the capital stock from the previous period depreciated at a rate δ_t:

$$K_t = (1 - \delta_t) K_{t-1} + I_t \tag{21}$$

In principle, this method can be applied at both aggregate and sectoral levels where the relevant investment and depreciation rates are known. Note, however, that no adjustment is contemplated for either short- versus long-lived capital or for differences in the marginal productivity of different types of capital asset. Thus, the sub-factor shares necessary to estimate a translog index equivalent to equation (7) are taken as being equal to the simple weight of public and private capital in aggregate fixed capital.

6.1. Aggregate fixed capital

The investment figures necessary to estimate equation (21) on an economy-wide basis must be collated from various sources as a consistent historical time series for the entire period is not available. Thus, gross nominal investment is taken from the most recent INE GDP series covering the period 1991-2004. To continue backwards to 1980 one then applies the annual rate of variation in gross nominal investment also published by in various official statistical annuals (INE, anuários estatísticos) but which do not constitute a consistent series. To calculate real investment, nominal values are deflated by a constructed index which, for values outside the consistent 1991-2004 INE series for which investment price changes are provided, is calculated as varying in line with the exchange rate (85% weight) and real GDP (15% weight).[15]

The depreciation rates required for the capital stock calculation are allowed to vary in order to account for the impact of the civil war which witnessed substantial destruction of public and private property and large-scale population movements. While this is a departure from most studies, it naturally is not possible to calculate with any degree of precision the real depreciation rates associated with the war. At the same time it is beyond doubt that "normal", constant aggregate depreciation rates of around 5%, applied both internationally and to Mozambique (e.g IMF, 2005; Sulemane, 2001), give an upwards bias to the overall capital stock estimates. Therefore we roughly assume that aggregate real deprecation rates peaked at 10.5% per annum during the height of the war, falling to 5% in the post-war period and with a spike in 2000 to capture the effect of damaging floods.

[15] The real GPD series already presented (figure 1) is calculated in the same way as the real investment series. However, real GDP deflators for the period prior to 1991 are taken from Sulemane (2001).

Finally, to calculate the starting value of the capital stock we employ the approach of Young (1994) who states that according to the perpetual investment method, the capital stock at time t=0, being the first year in a given series, can be estimated as:

$$K_o = \sum_{i=0}^{\infty} I_{-i-1}(1-\delta)^i = I_0 / (g+\delta) \qquad (22)$$

where δ is a constant rate of depreciation and g is the average rate of growth in investment for the first five years of the series. In the Mozambican case we set $\delta=5\%$ and $g=0\%$ to estimate K_0 for 1973, being the peak of real production in the pre-Independence period and also being prior to considerable changes associated with the rapid Portuguese settler withdrawal in 1975.[16]

6.2. Government fixed capital

Although the decomposition of the capital stock between the public and private sectors is not found frequently in the literature, various studies have focussed solely on the estimation of the government stock (e.g. Kamps, 2004). In such cases, the estimation procedure proceeds in exactly the same fashion as section 6.1. For Mozambique, the nominal government investment figures are taken from government budget execution accounts (INE, 2005) deflated by the aggregate investment deflator described above. These, however, must be adjusted due to the misleading distinction between the government's "current" and "investment" budget accounts. The latter covers (among other things) externally-financed projects which often include a mixture of recurrent and investment activities. Thus, the budgeted total investment figure should be adjusted downwards to give a more robust estimate of true investment. However, as reliable annual estimates of the proportion of the investment budget associated with recurrent activities are not available, we assume this has fallen from 50% in 1980-1992 to 30% in 2004, the latter being consistent with figures for the 2005 budget (República de Moçambique, 2005a) and the former being associated with higher-levels of military expenditures during the war. Thus, we assume post-war declines in this adjustment factor reflect the shifting priorities of the government from military towards more economically productive investment.

[16] The depreciation rates in 1975 and 1976 are set at 10% and 8% respectively to reflect the rapid exit, and in some cases destruction of capital assets of many Portuguese settlers from agricultural and industrial production at Independence (see Tarp, 1984).

The depreciation rates used for the government sector are higher than those used for the economy as a whole in order to account for deliberate damage inflicted on public infrastructure during the civil war. Government estimates of the early 1990s, quoted in Brück (1997), suggest that annual destruction of core government buildings such as schools and health posts averaged at around 6% per annum during the war years. Thus, we estimate public infrastructure depreciation (including both destruction and normal declines in value) peaked during the height of the war at 12.8%, falling to 5% in the post-war period with a similar spike in 2000 due to the floods.

We calculate the starting value of this series in 1975, being the first year for which government investment data is available. Thus, setting $\delta = g = 5\%$ in equation (22) the 1980 real value of government capital stock is equivalent to 20% of total fixed capital. Figure B.1 shows the resulting trends in the two capital stock categories and figure B.2 shows the different depreciation rates for the two sectors.

7. GROWTH ACCOUNTING ESTIMATION

7.1. Aggregate factor shares

The final step in the exercise is estimation of the marginal productivities of aggregate labour and capital, usually proxied by their share in output (Barro, 1998). As we have seen, it is usual to assume these add to unity with labour representing a constant share of output at around 60% (e.g. IMF, 2005). It is necessary, however, to examine the validity of this assumption before proceeding not only on grounds of rigour but also in recognition that both capital and labour stocks have experienced *unequal* rates and directions of change during the period. This is confirmed in part by the social accounting matrices developed for the post-war period which estimate the fixed capital share of total factor income has fallen from approximately 40% in 1995 to 30% in 2002 (see Arndt et al., 1998; Arndt et al., 2000b; Tarp et al., 2002), suggesting the civil war period may have been associated with a higher fixed capital share than currently observed. This trend would be consistent with an increase in the relative scarcity and therefore relative price (rental rate) of fixed capital beyond any increases in its average product. Both the destruction of fixed capital during the civil war and reductions in the *average* wage associated the temporary dislocation of rural populations to urban areas would be compatible with this hypothesis.

Unfortunately, however, there is no quick-and-easy methodology for accurately estimating factor shares, particularly in the available GDP income data for Mozambique which includes a large category of 'mixed family income' ("rendimento misto de famílias") associated with informal sector, normally agricultural income attributed neither directly to capital nor to labour. Certainly this data can set the broad parameters within which we can expect the shares to fall. For 1996, for example, the share of GDP at factor cost unambiguously attributable to labour is 17.3% (rising to 31.9% in 2003) and 23.7% to capital (which remains more or less stable through to 2003). This means that we would consistently need to attribute 80% of 'mixed family income' to labour to ensure labour's share remained at approximately 60% in total. This is not implausible given the low-level of capital input, aside from land, in informal production. However, there is no straightforward evidence to justify the choice of 80% (against 75% for example) and this approach does not take into account the potential for movements in the factor shares.

Thus, in order to capture the changing pattern of labour and factor accumulation associated with structural change in the pre- and post-civil war periods we allow the labour and factor shares to move according to their relative scarcities. Explicitly, employing the values for aggregate capital (*K*) and quality-adjusted labour (*Lh*) already calculated, we assume the capital share in time *t* is given by:

$$s_{kt} = s_{kt-1}\left(2 - \frac{K_t / K_{t-1}}{\left(L_t h_t\right) / \left(L_{t-1} h_{t-1}\right)}\right) \tag{23}$$

where the labour share in each period is calculated as $s_{lt} = 1 - s_{kt}$ to ensure constant returns to aggregate factor inputs. This shows that where the capital stock is growing *faster* than the adjusted-labour stock then the share of capital falls by the relative difference in their growth rates. Finally, we fix the capital share at 60% in 1992, consistent with a share of capital declining to 30% by 2004.[17] The resulting share of labour used in the translog specification is shown in figure B.3 together with the rate of change in the ratio of the capital and adjusted-labour stock growth rates. For the comparative Cobb-Douglas exercise, however, we set the labour and capital shares

[17] Note production function regressions of the form (in logarithms): $Y = A + \alpha K + \beta(hL)$ applied to the data also indicate a relatively high *average* capital share in the region of 70% for the period. These regressions also provide support for constant returns to aggregate factor inputs.

constant at 60% and 40% respectively, thus following the more "standard" approach of other studies.

7.2. Results

Table 3: Summary of principal results, % of average annual growth in GDP explained by each variable

Specification	Period	TFP	Capital	Labour	Education
A. Translog	1993-2004	43.0	47.1	9.9	-
	1999-2004	37.9	53.1	9.0	-
	1981-2004	26.0	48.7	25.3	-
B. Cobb-Douglas	1993-2004	45.4	43.3	11.3	-
	1999-2004	35.0	56.6	8.4	-
	1981-2004	23.8	45.6	30.7	-
C. Translog	1993-2004	34.6	47.1	9.9	8.4
	1999-2004	24.0	53.1	9.0	13.9
	1981-2004	10.6	48.7	25.3	15.5
D. Cobb-Douglas	1993-2004	36.7	43.3	11.3	8.7
	1999-2004	21.8	56.6	8.4	13.2
	1981-2004	7.1	45.6	30.7	16.6

Note: Specifications A and B exclude quality (education) adjustments to labour inputs; for specifications C and D 'Education' is equivalent to the change (fall) in TFP once a quality-adjusted human capital index is included in addition to the pure stock of labour, *L*.

Table 4: Disaggregated translog. results, annual average log. growth in %

	Real GDP	TFP	Fixed Capital		Human Capital	
	Y	A	Govmt.	Private	Unskilled	Skilled
1993-2004	7.5	2.6	1.0	2.5	0.0	1.3
% Y	100.0	34.6	13.5	33.6	0.6	17.8
1993-1998	7.6	3.4	1.0	2.1	0.4	0.7
% Y	100.0	44.8	12.9	28.3	5.1	8.9
1999-2004	7.4	1.8	1.0	2.9	-0.3	2.0
% Y	100.0	24.0	14.1	39.1	-4.1	27.0
1981-2004	2.6	0.3	0.5	0.7	0.1	0.9
% Y	100.0	10.6	20.4	28.3	5.8	35.0

Tables 3 and 4 present a summary of results from the two approaches covering both the post-war period and the full period since 1980; tables A.4 – A.9 (annex A) provide more detailed information. Specifications A and B of table 3 describe the base-line results from the Cobb-Douglas and translog specifications *before* adjusting for labour quality (see also tables A.4 and A.5). In these estimations labour inputs are taken as the raw active working age population. Unsurprisingly, the results are highly alike – the main difference (methodologically) being due to the use of variable aggregate factor shares in the translog specification. A brief examination of these results shows they are highly comparable to those of IMF (2005) both for the full 1981-2004 period and the post-war period. This indicates the consistency of the underlying data series with previous studies as well as the broad comparability of the Cobb-Douglas and translog approaches at high levels of aggregation.[18]

The quality-adjusted results in specifications C and D (also table 4 and A.6) indicate the important role of human capital quality improvements. In the presentation in table 3 the 'education' column gives the exact decline in the TFP residual once we include the quality-adjustment associated with education. As a result, the column gives the pure gain from education which is shown to have had an important and *growing* impact on growth during the post-war period. For example, from the translog specification the contribution of education is 8.7% during the post-war period a result broadly consistent with the 7% contribution of education found by Benito-Spinetto and Moll (2005) for 1997-2002.

As the translog approach permits the calculation of the contribution of different factor sub-categories to overall growth, tables A.8 – A.9 present a more detailed breakdown. In each table we show not only the individual contribution of each sub-category to changes in output during the period but also the contribution to each aggregate factor input category (e.g. capital) of its constituent sub-categories. For example, according to table A.8, while total fixed capital accumulation accounts for 48.7% of overall growth from 1981-2004 movements in government capital stocks explain 20.4% of overall growth. This is equivalent to 41.9% of the contribution of total fixed capital a figure substantially higher than the 27% average weight (income share) of government capital in aggregate fixed capital for the period.

A graphical summary of the disaggregated results from the full translog approach is given in figure B.4. The graph sketches trends in the principal variables constructed from log growth rates indexed at 1980 = 100. As can be seen, the civil war period is associated with substantial falls in both the aggregate capital stock (*K*) and the TFP index (*A*) despite slow gains in unskilled (*U*) and skilled labour stocks (*S*). The post-war period is starkly different with strong gains particularly evident for capital and

[18] Indeed, it can be shown mathematically that the two approaches are exactly equivalent for constant factor shares.

skilled labour stocks; the TFP residual shows a robust recovery to slightly above its 1980 level.

7.3. Analysis

This section discusses the main analytical and methodological issues arising from the findings. First, as indicated above, the results show strong returns to education at the level of aggregate output. For the period as a whole (1981-2004), pure educational improvements account for 15.5% of observed growth; however, this result should be treated with caution as it relates in part to the fact that while output declined steadily during the civil war period, both labour stocks and education indices gradually increased. The post-war phase is more appropriate for analysis and clearly shows a *rising* contribution of education to growth consistent with known improvements in both enrolment and efficiency rates (MPF and MINED, 2003). Of particular interest is the 13.9% contribution of education to growth for 1999-2004 which, according to cross-country studies (see Benito-Spinetto and Moll, 2005: 48-49), represents a relatively high return to education for a developing country and testifies to the enormous progress made in expanding the education system initiated during the war years and pursued more successfully since 1992. This is underlined when we recall, according to the estimates developed here, that in 1980 a staggering 91% of the economically active working population had no educational qualifications whatsoever. By 1992 this had fallen to 86.2% and in 2004 was approximately 77% - a fall of 9 percentage points in the post-war period alone. This also highlights that from a population-perspective educational improvements take time and are highly path-dependent. Thus, *early* investments in the education system in both conflict and post-conflict situations are likely to be essential to support future economic growth.

Second, the results indicate we must be sensitive to the structure of improvements in the work force. This can be seen from the breakdown of human capital growth between skilled and unskilled labour in table 4 which shows very weak growth in unskilled labour since the civil war and a negative contribution (-4.1%) of this category from 1999-2004. The latter result is revealing as it indicates that the expansion of the education system has reached a point where the number of new additions to the unskilled work force is lower than reductions through either death or attainment of an educational qualification. In other words, due to the much higher coverage of primary education the number of workers without any education has been falling in absolute terms. This result is confirmed by a 1.5% absolute fall in this stock registered between the 1997 census and the 2002/03 IAF survey.

Further exploiting the more finely differentiated results from the translog approach, table A.9 gives a breakdown of the sub-components of the skilled labour index, showing that nearly 80% of the growth gains from skilled labour in the post-war period can be associated with improvements in urban education. This result is a function of three effects – the higher wage premia associated with urban as opposed to rural education, the higher proportion of educated members of the workforce found in urban areas and the relocation of rural workers to urban areas during the period. Indeed, the population shift out of rural areas has not been insignificant – we estimate that while 79.2% of the active working population were located in rural areas in 1980, this had fallen to 68.5% by 2004. We also find that the contribution to growth from the skilled workforce during the post-war period has been *increasingly* driven by secondary-level education (for both urban and rural areas), suggesting that further expansion of education at this level and beyond will be necessary to support future employment needs and the demands of modern technology. It is also noteworthy that in rural areas the contribution to skilled labour has come mainly from workers educated to a primary level – a result of the comparably low expansion of secondary schooling in these areas. Of course, the implications of these results for future education policy are by no means straightforward; however, they indicate the likely existence of trade-offs between the wholesale expansion of education at all levels in all areas against targeted interventions aimed at more specific population segments.

Third, at an aggregate level it appears incontrovertible that the recovery and later expansion of fixed capital stock has been a foundation of post-war growth. Indeed, as with skilled human capital, growth here has played a larger contribution in later as compared to earlier post-war phases – e.g. for 1993-98 capital accumulation explains 41.2% of growth rising to 53.1% for 1999-2004. The breakdown of capital growth between the government and private sectors also points to an interesting trend, namely that while the accumulation of private sector capital has remained dominant in aggregate terms, government sector investment played a larger relative role in the immediate post-war period, (see table 4 and table A.8). This may indicate a degree of crowding-in of private sector investment, at least in a post-conflict setting, as well as the critical function of public infrastructure reconstruction for the reestablishment of broad/deep markets and reduction of transaction costs. This trend might also suggest that the credibility of government investment and the stability of peace need to be proven before private sector investment recovers.

Fourth, once human capital accumulation is included growth in what might be considered TFP or technical advancement is more moderate. For the post-war phase TFP growth explains a reasonable 34.6% of growth, consistent with the realisation of peace, the return of dislocated populations and the reestablishment of internal markets. These TFP increases therefore suggest a robust recovery in the production possibilities frontier that had been weakened by civil war. Two results, however, would indicate that these rates of TFP growth may not be guaranteed for the future. In the later post-war phase the contribution to GDP growth of changes in TFP fell by 46% compared to the early post-war phase to 24.0%, a sign of a slowing rate of improvement. Second, in the long-view since 1980 the aggregate change in TFP has not been strong, explaining only 10.6% of growth. Of course, changes in the TFP term capture more than just technology and this result is consistent with the effects of civil war and a succession of natural disasters from 1980 to 1992. Indeed, as shown in figure B.4, all the large falls recorded in the TFP index during the full period (in 1982-83, 1991-92 and 2000) correspond to natural disasters. However, even when one attempts to estimate the long-term, 'true' time trend adjusted for short-term fluctuations (see figure B.5) the story remains that TFP only has recovered from its level in 1980. This might, in a suggestive sense, corroborate with the World Bank's (2005) analysis that Mozambique cannot continue to rely on post-war recovery to drive growth; rather, more concerted and policy-driven interventions, particularly in the area of natural resources, must be made in order to maintain strong real output growth. It would also support Tahari et al.'s (2005) general analysis that TFP growth has not played a substantial role in modern growth experiences of sub-Saharan African countries. Further, the short-term fluctuations in TFP growth rates point to the continued vulnerability of the economy to production shocks caused by climatic disturbances.

Fifth, from a methodological perspective this paper demonstrates the acute sensitivity of any growth accounting exercise to the quality of the underlying data as well as the implicit assumptions used in building these data series. The philosophy adopted here is that while economic investigation is constrained by a lack of consistent quality data, as in Mozambique, the careful analyst can employ a variety of tools to develop reasonable and consistent estimates for missing or weak data. It is also worth pointing-out that where growth accounting data is to be used for country-specific analysis, this data is best developed with an understanding of local conditions and histories, such as in the case of adjusting capital depreciation rates to reflect civil war related damage.

Sixth, and as expected, the translog and Cobb-Douglas approaches do not generate wildly different results with the same underlying data. This also extends to the construction of the different human capital measures used here. It is clear, however, that the translog specification is to be preferred given its greater flexibility, particularly in the development of accurate sub-categories for analysis in the sense that it allows the estimation of the contribution to growth of, for example, that part of the urban working population with a secondary school education or above.

Finally, one can point out some deficiencies in the above analysis. First, and probably most crucial, is the lack of robust employment data concerning the intensity of employment among the active working-age population. This is particularly relevant in our case as the civil war was associated with substantial dislocation of rural populations. Implicit in our approach, however, is the assumption that the intensity of employment is captured by the wage premia estimates; however this is likely to be only a crude approximation. At this stage no labour force survey data explicitly concerned with employment patterns is available. Second, we assume the wage premia are constant throughout the period – also a crude assumption given the extreme scarcity of skilled personnel in the early part of the period. Logically, if the premia were historically higher, reflecting such elevated scarcity, then some of the gains from education observed in this study may be diluted moderately. Lastly, it is evident that the analysis would benefit from further investigation of the TFP term with emphasis on isolating exogenous influences and a deeper understanding of the determinants of TFP growth.

8. CONCLUSION

This paper has examined the growth experience of Mozambique since 1980. It shows that human capital improvements, made possible by the expansion of the education system during the civil war and beyond, have played a critical role in the rapid economic growth of the past decade. Furthermore, both government and private sector investment jointly have contributed to over 45% of observed post-war growth. At the same time, although TFP growth has been robust in the post-war period consistent with gains from the shift to a more stable post-conflict environment, it is not yet evident whether such trends represent a firm basis to support economic growth beyond post-war recovery.

Methodologically this paper has indicated the sensitivity of growth accounting exercises to the quality of the underlying data and the assumptions used in their construction. As expected, although the translog approach has been shown to be more adaptable and extendible, both the translog and Cobb-Douglas specifications generate similar results from the same base data. Thus, the observed variability of results in growth accounting studies derives less from the accounting specification and more from this base data. In developing country situations where historical experiences are highly diverse, and often peppered with structural shocks, it is therefore apparent that careful construction of the underlying data in sensitivity to these historical events is to be preferred.

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Annex A: Additional tables

Table A.1: Position probability matrix derived from 2001 transition matrix

	class 1	class 2	class 3	class 4	class 5	class 6	class 7	class 8	class 9	class 10	exit	total
class 1	7.5	14.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	23.1
class 2		5.0	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	19.1
class 3			4.4	9.6	0.0	0.0	0.0	0.0	0.0	0.0	2.7	16.7
class 4				2.7	7.8	0.0	0.0	0.0	0.0	0.0	1.8	12.4
class 5					2.0	5.0	0.0	0.0	0.0	0.0	2.8	9.8
class 6						1.7	3.6	0.0	0.0	0.0	1.4	6.7
class 7							1.5	2.2	0.0	0.0	1.4	5.1
class 8								0.9	1.5	0.0	0.6	3.0
class 9									0.5	1.3	0.3	2.0
class 10										0.8	1.3	2.0
total	7.5	19.1	16.7	12.4	9.8	6.7	5.1	3.0	2.0	2.0	15.6	100.0

Table A.2: Results of human capital stock estimates

				Unskilled labour		Skilled labour, by max. education level			
	W	W_{act}	W_{act}	Urban	Rural	EP urban	EP rural	ES urban	ES rural
	' 000s	' 000s	% W	% W_{act}		% W_{act}			
1980	6,428	5,660	88.1	13.7	75.8	5.7	3.2	1.4	0.2
1985	6,872	5,979	87.0	14.2	72.8	7.1	4.4	1.3	0.2
1990	7,363	6,349	86.2	14.7	70.0	8.2	5.4	1.4	0.2
1995	8,076	6,924	85.7	15.3	67.6	8.8	6.3	1.8	0.3
2000	8,790	7,459	84.8	15.3	63.6	10.1	7.9	2.5	0.5
2004	9,288	7,765	83.6	15.0	57.5	12.4	10.2	4.1	0.8

Table A.3: Results from regressions used to estimate returns to education

	Household-based			Individual-based		
Dependent Var.	Household consumption (log)			Per capita consumption (log)		
F statistic	153.85			207.43		
R-squared	37.7%			33.9%		
Variable	Coeff.	t	P>t	Coeff.	t	P>t
None (urban)	0.06	0.71	0.48	0.34	6.07	0.00
EP (urban)	0.75	16.01	0.00	0.87	19.44	0.00
EP (rural)	0.21	5.40	0.00	0.21	6.90	0.00
ES (urban)	1.56	21.25	0.00	1.62	22.70	0.00
ES (rural)	0.82	8.10	0.00	0.74	5.93	0.00
Household size	0.72	11.94	0.00	-1.01	-15.49	0.00
No. dependents	-0.19	-4.49	0.00	0.77	18.94	0.00
Age	0.08	2.06	0.04	0.09	4.26	0.00
Intercept	1.13	7.38	0.00	2.22	17.95	0.00

Note: F statistics are significant at 1% level; all variables other than education dummies are in log form

Table A.4: Results for an alternative human capital measure

	L	h	Lh
1980	5,660	1.2	6,595
1985	5,979	1.2	7,073
1990	6,349	1.2	7,653
1995	6,924	1.2	8,517
2000	7,459	1.3	9,571
2004	7,765	1.4	10,738

Table A.5: Cobb-Douglas results excluding education, annual average growth in %

	Real GDP Y	**TFP A**	**Capital K**	**Labour L**
1993-2004	**7.5**	**3.4**	**3.2**	**0.8**
% Y	100.0	45.4	43.3	11.3
1993-1998	7.6	4.2	2.3	1.1
% Y	100.0	55.5	30.3	14.2
1999-2004	7.4	2.6	4.2	0.6
% Y	100.0	35.0	56.6	8.4
1981-2004	**2.6**	**0.6**	**1.2**	**0.8**
% Y	100.0	23.8	45.6	30.7

Table A.6: Translog results excl. education-based decomposition, annual average growth in %

	Real GDP Y	**TFP A**	**Capital K**	**Labour W_{act}**
1993-2004	**7.5**	**3.2**	**3.5**	**0.7**
% Y	100.0	43.0	47.1	9.9
1993-1998	7.6	3.6	3.1	0.8
% Y	100.0	47.9	41.2	10.9
1999-2004	7.4	2.8	3.9	0.7
% Y	100.0	37.9	53.1	9.0
1981-2004	**2.6**	**0.7**	**1.3**	**0.7**
% Y	100.0	26.0	48.7	25.3

Table A.7: Cobb-Douglas results incl. education, annual average growth in %

	Real GDP Y	**TFP A**	**Capital K**	**Labour L**	**Education h**
1993-2004	**7.5**	**2.7**	**3.2**	**0.8**	**0.6**
% Y	100.0	36.7	43.3	11.3	8.7
1993-1998	7.6	3.9	2.3	1.1	0.3
% Y	100.0	51.1	30.3	14.2	4.3
1999-2004	7.4	1.6	4.2	0.6	1.0
% Y	100.0	21.8	56.6	8.4	13.2
1981-2004	**2.6**	**0.2**	**1.2**	**0.8**	**0.4**
% Y	100.0	7.1	45.6	30.7	16.6

Table A.8 Decomposition of translog results for capital inputs, annual average growth in %

	Real GDP	Capital stock (K)		
	Y	Govt.	Private	Total
1993-2004	**7.5**	**1.0**	**2.5**	**3.5**
% K	-	28.6	71.4	100.0
% Y	100.0	13.5	33.6	47.1
1993-1998	7.6	1.0	2.1	3.1
% K	-	31.2	68.8	100.0
% Y	100.0	12.9	28.3	41.2
1999-2004	7.4	1.0	2.9	3.9
% K	-	26.5	73.5	100.0
% Y	100.0	14.1	39.1	53.1
1981-2004	**2.6**	**0.5**	**0.7**	**1.3**
% K	-	41.9	58.1	100.0
% Y	100.0	20.4	28.3	48.7

Table A.9: Decomposition of translog results for skilled labour inputs, annual average growth in %

	Real GDP	Skilled Labour Stock (S)				
	Y	Rural ES	Rural EP	Urban ES	Urban EP	Total
1993-2004	**7.5**	**0.1**	**0.3**	**0.6**	**0.5**	**1.3**
% S	-	3.8	19.1	42.0	35.2	100.0
% Y	100.0	0.7	3.4	7.5	6.3	17.8
1993-1998	**7.6**	**0.0**	**0.2**	**0.2**	**0.3**	**0.7**
% S	-	3.2	22.8	35.3	38.6	100.0
% Y	100.0	0.3	2.0	3.1	3.4	8.9
1999-2004	**7.4**	**0.1**	**0.4**	**0.9**	**0.7**	**2.0**
% S	-	3.9	17.8	44.2	34.0	100.0
% Y	100.0	1.1	4.8	11.9	9.2	27.0
1981-2004	**2.6**	**0.0**	**0.2**	**0.3**	**0.4**	**0.9**
% S	-	3.1	21.4	33.6	41.9	100.0
% Y	100.0	0.8	4.6	9.1	8.6	23.0

Annex B: Additional figures

Figure B.1: Aggregate capital stock by sector 1980-2004, in 10^9 Mt at constant 1980 prices

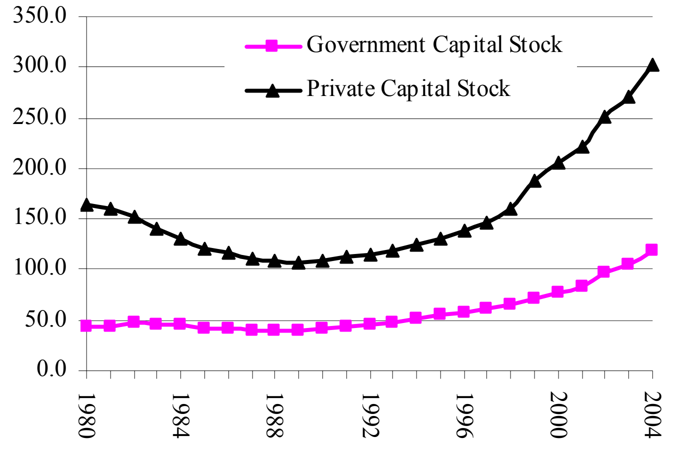

Figure B.2: Trends in real rates of capital stock depreciation (%) by sector, 1980-2004

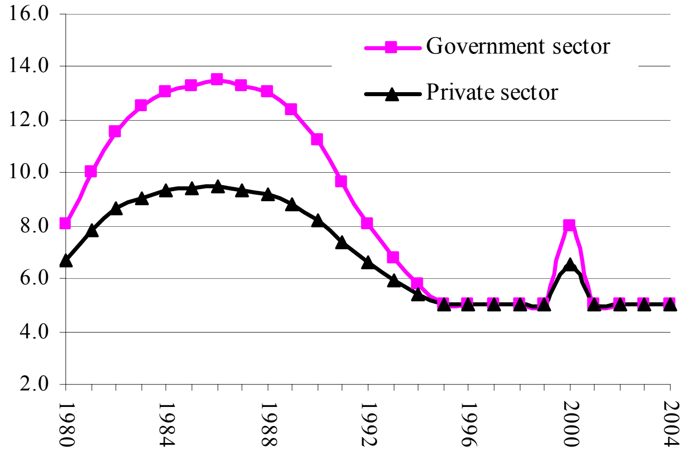

Figure B.3: Aggregate labour share in total output (RHS) vs. ratio of growth in aggregate capital vs. labour (LHS), 1980-2004

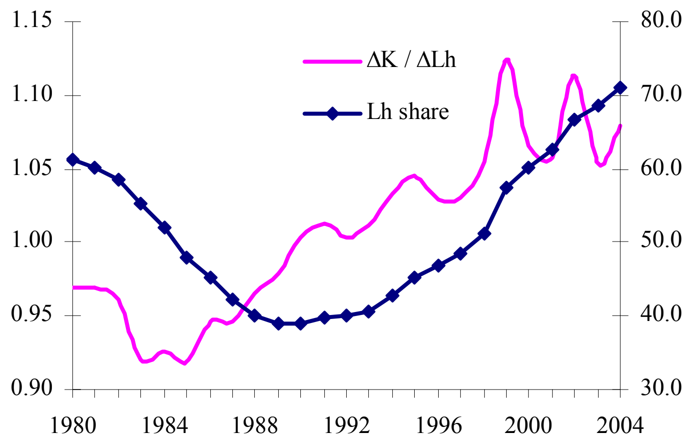

Figure B.4: Trends in translog indices incl. estimated residual (1980 = 100)

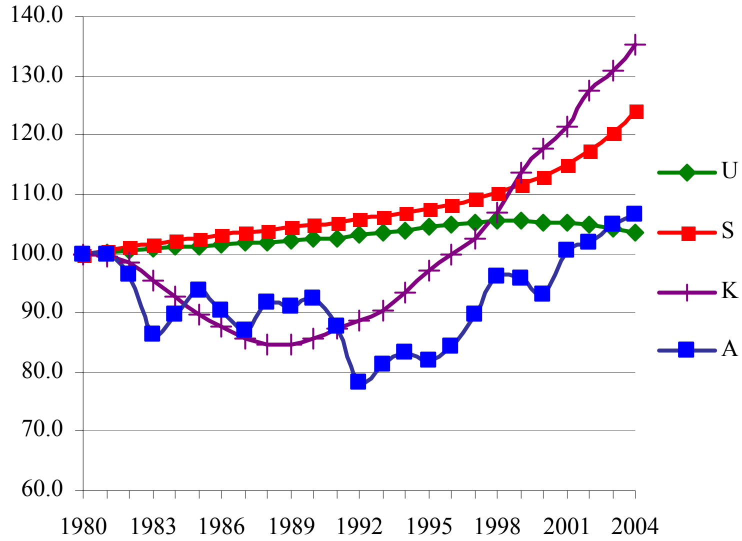

Figure B.5: Original and (Hodrick-Prescott) filtered TFP residuals estimated from translog procedure (see table A.7) (indexed, 1980 = 100)