Civil Wars, Human Capital and Economic Growth: A SUR Approach

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Abstract

This study investigates the relationships between civil war, human capital and economic growth using econometric approach. This study first examines whether the initial level of *human capital* of population can help to prevent civil war onset by applying single equation logit analysis. The findings show that the level of initial human capital is a significant factor that substantially decreases the risk of civil war onset. Then the Seemingly Unrelated Regression (SUR) approach is applied to simultaneously estimate the system of *output growth* and *civil war* equations. The empirical result is based on a panel data consisting of 107 countries observed at five-year intervals from 1960 to 1995. This analysis finds that the initial level of human capital is not only a factor that contributes to economic growth but it also decreases civil war risks, thereby improving the economy's environment for economic activities.

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1. Introduction

The question of whether and how human capital affects economic growth has captured the attention of many researchers. In endogenous growth theory literature, the growth of total factor productivity or technological progress is modeled as a function of human capital or the level of education. This model assumes that the higher the level of education the labour force has, the better in creating, implementing, and adopting new technologies, which in turn contributes to economic growth. Another common approach in examining the growth effect of human capital is often called an augmented Solow model, which is suggested in Mankiw, Romer, and Weil (1992). The augmented Solow model approach includes human capital as an additional factor of the production function of economies. (Benhabib and Spiegel, 1994) and is used by many researchers including Islam (1995) and Caselli et al. (1996).

Due to its potential impact on output growth, the influence of human capital on economic growth has also been examined in the context of developing economies. For example, Easterly and Levine (1997) examined whether the slow economic growth of Sub-saharan Africa was attributed to low human capital. They found that the poor output growth of Sub-saharan Africa, which he referred as Africa's Growth Tragedy, is associated with low schooling along with other factors such as political instability, poorly developed financial systems, large government deficits, and inadequate infrastructure. If human capital is indeed an important factor of economic growth, policies that promote the acquisition of education or schooling may contribute to the long-term output growth of developing countries that have a low stock of human capital through increasing their level of human capital in the future.

For countries that have experienced, are currently experiencing, or are highly prone to experiencing civil wars in the near future, however, enhancing the human capital investment by individuals to increase the level of human capital stock that will contribute to output growth, is not easy at all. This is because human capital investment, in fact, is a decision variable in which the vulnerability of society to civil wars may negatively influence one's decision to acquire more schooling. If countries have previously experienced civil wars, the incidence of previous civil wars may have had both direct and indirect effects on decreasing the level of investment in schooling. Students might have been internally displaced when civil wars occurred and their schooling discontinued as a result of civil wars. This would directly lower the level of school enrolment of young population as well as level of human

capital in the current period. That civil wars tend to reoccur once they ever occur, often called *Conflict Trap*, might have decreased the expected returns to schooling because of the uncertainty of the future caused by risks prevalent to such post-conflict societies. Likewise, current civil wars both indirectly and directly decrease current and future schooling investment, and thus the level of human capital in the future. When a society faces great risks to civil wars, the expected returns to schooling is low because of uncertainty associated with the risks.

An example of linking schooling and the likelihood of civil war onsets is Collier and Hoeffler (2004). They found that *secondary male enrolment*, used as a proxy for forgone income for the male youth, the potential target group of rebel recruits, is an important factor that decreases the risk of civil war onset. Recognizing that the secondary school enrolment rate is a frequently used variable as a measure of human capital in the economic growth literature has led to interesting questions: is human capital an important factor to decrease the risk of civil war onset? Does the strong positive association of secondary male enrolment indicate that the human capital in the male population influences the prevention of civil war onset significantly more than the human capital in the general population? To examine these questions, however, one needs to think carefully about what enrolment rate actually measures because enrolment as a measure of human capital may mean two different effects: accumulation and level effects of human capital as pointed out by Gemmell (1996) and Temple (1999).

With the possibility that enrolment rates contain accumulation effects, the reverse causation issue cannot be avoidable – the riskier (the less riskier) a society is in terms of civil war occurrence, the lower (the higher) the expected returns to schooling is, and the lower (higher) the school enrolment rates of current period. In other words, the negative association between secondary male enrolment can not only be interpreted as ‘the higher the forgone income when one rebels, the less likely one to rebel’ but also as ‘the more prevalent rebellion is, the more prone to civil wars a society and the population are, the less incentives to invest more in schooling under risky circumstances.’ Due to this possibility of reverse causality, *secondary male enrolment* can be a poor measure in examining the question of whether human capital promotes a less risky society. A better measure could be the level of education or human capital stock in the beginning of the period in that the occurrence of civil war onset in a given

time period or interval does not cause the initial stock or level of human capital measured at the beginning of the period. [1]

Motivated by Collier and Hoeffler (2004)'s important finding and the availability of using a possibly better proxy, this study asks the question: Does the given level of a society's human capital in the beginning of the period can be a factor that helps prevent civil wars from occurring? In other words, can the level of human capital, which is a factor of output growth, also help prevent the onset of civil wars, and in turn make a society a better environment for economic activities?

To answer these questions two equations are combined and estimated as a system of equations. The first equation, suggested by Mankiw et al. (1992), is an augmented Solow model for output growth in which human capital is a factor of production function The second is a linear equation that attempts to explain the proneness to civil war onsets following Collier and Hoeffler's (2004) seminal paper on the economics of conflict, In the following section, different measures of human capital, the data sources used, and the construction method of the estimation data set of this study are presented, followed by the description of variables. Section 3 briefly introduces the augmented Solow growth model that is estimated in this study, followed by examination of the link between the level of human capital and civil war onset in Section 4. In section 5, the estimation model, SUR (Seemingly Unrelated Regression) system of *output growth* and *civil war equations* is introduced. Section 6 presents the estimation result and Section 7 provides summary and conclusions.

2. Human Capital Measure, Data and Variables

Human Capital Measure

A fundamental methodological issue facing researchers who want to investigate the output growth effect of human capital is how to define and measure human capital. The proxies that are often used in economics literature range from literacy rates, the number of graduates,

[1] However, as the concept of 'conflict trap' indicates, the start of civil war in period t can be highly correlated with the previous experience of a civil war in t-1 (or earlier periods), which would decrease the accumulation of human capital in t-1 (or earlier periods), which would then influence the stock or level of human capita in t.

average years of education, school enrolment ratios or the proportion of the population that has completed schooling at different levels of education. Amongst these measures, the secondary-school enrolment ratio is very frequently used as in Mankiw et al. (1992), Caselli et al. (1996) and Bond et al. (2001) although it is subject to criticism. For example, it is argued that school enrolment rates may have mixture of both human capital stock and accumulation effects and hence may not be a good proxy for either stock or accumulation effects of human capital (Gemmell, 1996; Temple, 1999).

Data

The dataset constructed for this study is based on three different sources including Barro-and Lee data set. Barro and Lee (2001) have constructed a data set which contains information about the data on educational attainment at various levels for a broad number of countries in the world estimated at five-year intervals for the years 1960-2000. That is, a total of 8 periods of time series for each country can be retrieved. This data set also contains the average years of schooling in the total population over age 25 and over 15, both of which are the main human capital measure used in this study. For the detailed description, see Barro and Lee (2000). The dataset can be retrieved from the website of the Center for International Development at Harvard University, http://www.cid.harvard.edu/ciddata/ciddata.html.

The second data source for the information on the variables in the growth equation such as per capita gdp, the investment rate, and population is the Penn World Table (PWT) 6.2 database, which provides purchasing power parity and national income accounts converted to international prices for 188 countries for some or all of the years 1950-2004. (Heston et al, 2006). Thirdly, variables used in the civil war equation are from Collier and Hoeffler (2004), which were retrieved from A. Hoeffler's research web-site, http://users.ox.ac.uk/~ball0144/research.htm. Collier and Hoeffler (2004)'s dataset contains information on data that are related to civil war risks estimated at five-year intervals for the years 1960-1995. Hence, a total of 7 periods of time series for each country can be obtained.

After merging three sources of datasets, the merged dataset contains 819 observations for 107 countries. However, due to many missing values of variables in both the 'civil war' dataset

and Barro-Lee datasets, a further 131 observations are lost when estimating the system of equations by SUR model. Hence, the system of equation estimation in this analysis only uses 688 observations.

Variables

The variables used in the empirical analysis of this paper are as follows:

Log Difference in Real GDP per Capita for Five-year Intervals: $\ln y_{i,t} - \ln y_{i,t-1}$

The real GDP per capita series (Chain, RGDPCH) are obtained from PTW 6.2.

Log of Initial per capita real GDP **:** $\ln(y_{i,t-1})$

Log of real GDP per capita at the beginning of each of 7 periods

Log of Population Growth Adjusted by Technical Change and Depreciation rate:

$\ln(n+g+\delta)$

Log of the population growth (n) adjusted by common exogenous rate of technical change (g) and common depreciation rate (δ). The value of $n+g$ is assumed to be 0.05 as in Mankiw et al. (1992).

Log of Physical Investment Rate: $\ln(s_t)$

Rate of physical investment is measured by the share of investment in real GDP (MRW,1992; Islam, 1995; Casellie et al., 1996; Hoeffler, 2002; Ding et al., 2008) The share of investment in real GDP was retrieved from PWT 6.2 and the average value of each five-year period is used.

Log of Human Capital

For the level of human capital in the beginning of each period, average years of schooling in total population over age 15 (tyr15) and over age 25 (tyr25) are obtained from the Barro-Lee dataset and used as proxies. See Barro and Lee (2000.)

Civil war onset

Following a conventional definition in empirical research suggested in (Singer and Small, 1984, 1994), a civil war is defined as an internal conflict in which at least 1000 battle-related deaths including both civilian and military occurred each year. Civil War Onset is a dummy variable which takes a value of one if the country experienced a civil war during each five year period. For further description of the definition and how it is measured, see Collier and Hoeffler (2004) and Singer and Small (1984, 1994).

Primary commodity exports/GDP (Sxp)

Sxp is measured as the ratio of primary commodity exports to GDP, which is considered as abundance of natural resources. The source of this variable is World Bank's World Development Indicator. For further description see Collier and Hoeffler (2004).

(Primary commodity exports/GDP(Sxp))Squared

The squared value of Primary commodity exports/GDP (Sxp).

Social fractionalization

Collier and Hoeffler (2004) proxy social fractionalization in a combined measure of ethnic and religious fractionalization. The measure includes the Ethno-linguistic Fractionalization Index (ELF), the variable first used by Mauro (1995) in the economics literature, and the religious fractionalization data from Barrett (1982). For the method of calculation used to combine these variables to generate Social fractionalization variable, see Collier and Hoeffler (2004).

Ethnic dominance

An indicator calculated by Collier and Hoeffler (2004) to take the value of one if a single ethno-linguistic group makes up 45 to 90% of the total population and zero otherwise. It is based on the ethono-linguistic data from the original data source from USSR(1964)

Peace Duration

A variable calculated by Collier and Hoeffler (2004) to measure the length of the peace period (in months) since the end of the previous civil war. For countries which have never experienced a civil war the authors measured the peace period since the end of World War II.

Ln(population)

Log of the total population. The population variable can be obtained from *World Development Indicators* (currently WDI 2008 is available) as well as PWT 6.2.

Mountainous terrain

The proportion of a country's terrain which is mountainous indicates the level of favourable environmental conditions for rebel groups to organize. (Collier and Hoeffler, 2004; Gerrad, 2000.)

Regional Dummies and Period Dummies

Because the size of the sample is very small, an attempt to estimate time-specific effects and country-specific effects by the panel data least-squares dummy variable (LSDV) estimator method, which requires creating time dummies for each period and country dummies for each country, may result in significant loss of degrees of freedom. Therefore, instead of including time dummies and country dummies for all time intervals and countries, I estimated period-specific and regional-specific effects instead. For period-specific effects, time dummies by decades, namely 60s, 70s, 80s and 90s, were generated. Regional dummies indicate whether a country belongs to Sub-saharan Africa, Latin American and Caribbean, South Asia, East Asia, Middle-east and North Africa, following the country classification by World Bank's WDI (World Development Indicator, 2008) data base.

Regional Dummies

dssa : A dummy variable indicating Sub-saharan Africa
dla: A dummy variable indicating Latin American and Caribbean
dsa: A dummy variable indicating South Asia
dea: A dummy variable indicating East Asia
dmen: A dummy variable indicating Middle-east and North Africa

Period Dummies:

d60, d70, d80, and d90

3. Human Capital and Output Growth – An Augmented Solow Model

An augmented Solow model suggested by Mankiw et al. (1992) can be written as follows:

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

Where, Y, K, L, A, H represent output, capital, labour, labour augmenting technological progress, and the stock of human capital. And decreasing returns to scale $\alpha + \beta < 0$ is assumed.

In terms of capital per effective unit, the model becomes:

$$\hat{y}(t) = \hat{k}(t)^{\alpha} \hat{h}(t)^{\beta} \qquad (2)$$

Where $\hat{y}(t) = \frac{Y(t)}{A(t)L(t)}$, $\hat{k}(t) = \frac{K(t)}{A(t)L(t)}$, and $\hat{h}(t) = \frac{H(t)}{A(t)L(t)}$ denote output per effective unit of labour, capital per effective unit of labour and human capital per effective unit of labour.

The augmented Solow model for growth in output per worker can be written as

$$\begin{aligned} &\ln y(t) - \ln y(0) = -\phi \ln y(0) + \phi \ln A(0) + gt \\ &+\phi \frac{\alpha}{1-\alpha-\beta} \ln(s_k) \\ &+\phi \frac{\alpha}{1-\alpha-\beta} \ln(s_h) \\ &-\phi \frac{\alpha}{1-\alpha-\beta} \ln(n+g+\delta) \end{aligned} \qquad (3)$$

where ϕ is $1-e^{-\varphi t}$, $\psi = (1-\alpha-\beta)\cdot(n+g+\delta)$ represents the speed of convergence in the augmented Solow model and s_k, s_h, n, and g represent share of income invested in physical capital (s_k) and in human capital (s_h), population growth (n), technological progress common across countries (g), and depreciation rate of capital (δ), respectively. It is assumed that $g+\delta$ is constant at 0.05.

In addition, Mankiw et al. (1992) suggested an alternative way of expressing the role of human capital in determining income in the model above. They combined equation (3) with the equation for the steady-state level of human capital,[2] $h^{ss} = \left(\frac{s_k^{\alpha} s_h^{1-\alpha}}{n+g+\delta} \right)^{\frac{1}{1-\alpha-\beta}}$ to get

$$\begin{aligned} \ln y(t) - \ln y(0) &= -\phi \ln y(0) + \phi \ln A(0) + gt \\ &+ \phi \frac{\alpha}{1-\alpha} \ln(s_k) \\ &+ \phi \frac{\beta}{1-\alpha} \ln(h^{ss}) \\ &- \phi \frac{\alpha}{1-\alpha} \ln(n+g+\delta) \end{aligned} \qquad (3a)$$

Note that (3a) expresses an equation for income as a function of *level* of human capital as well as the rate of investment in physical capital and the rate of population growth. Then, Mankiw et al. assumed that lnA(0)=$a+u$, where a is a constant and u is a country-specific shock.

To estimate the equation above by using a panel data analysis, one can rewrite the equation above, following Bond et al. (2001), as follows:

$$\ln y_{i,t} - \ln y_{i,t-1} = (\phi - 1) y_{i,t-1} + x_{i,t}^{'} \beta + \eta_i + \gamma_t + v_{i,t} \qquad (4)$$

for i=1,…,N and t=2,…,T.

Note that η_i, γ_t, $v_{i,t}$ represent the country-specific effects, time-specific effects, and a random error term. Also, $\ln y_{i,t} - \ln y_{i,t-1}$ represents the log difference in real per capita GDP over a five-year interval, $y_{i,t-1}$ represents the log of real per capita GDP at the beginning of each period, indicating the initial level of per capita GDP in each period, and $x_{i,t}$ is a vector of other explanatory variables measured at the beginning of each time period or as an average over each five-year time interval including the level of human capital, respectively.

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[2] The steady state level of both physical capital, $k^{ss} = \left(\frac{s_k^{1-\beta} s_h^{\beta}}{n+g+\delta} \right)^{1-\alpha-\beta}$, and human capital, $h^{ss} = \left(\frac{s_k^{\alpha} s_h^{1-\alpha}}{n+g+\delta} \right)^{\frac{1}{1-\alpha-\beta}}$, are obtained by solving two equations that describe the economy's evolution in steady state. See Mankiw et al. (1992).

4. Human Capital as technology to prevent civil wars

In Collier and Hoeffler (2004), *male secondary school enrolment*, one of the proxies of forgone earnings in rebellion, was an important variable that reduced the risk of civil war onset. The statistically significant effects of the *male secondary school enrolment* variable that reduced conflict risk were robust throughout different model specifications. Collier and Hoeffler (2004) interpreted this effect together with substantial and significant effects of other proxies of forgone earnings (i.e. namely per capita income and the growth rate) that low forgone earnings can facilitate conflict.

School enrolment rate is a measure or proxy of human capital that is often used in growth equations. Although school enrolment rate is not a highly accurate measure of human capital, it is highly correlated with average years of schooling, which is a measure of level of human capital stock. For example, in the sample of this study, the correlation coefficient between *male secondary school enrolment* and average schooling years in the total population of aged over 25 (aged over 15) was 0.831 (0.831). If one uses male secondary school enrolment as a proxy for human capital, the result found in Collier and Hoeffler (2004) may indicate that human capital not only has a direct impact on growth but also an indirect effect through decreasing the risk of conflict, a hindrance of economic growth. This can be expressed as the following, an empirically testable hypothesis:

Hypothesis: The higher level of education the labour force of a given population has, the less prone the society is to civil war risks.

In other words, the hypothesis examines whether human capital stock in the beginning of each period, a determinant of economic growth, is also a factor that decreases the civil war risk. To investigate this hypothesis, a common approach would be to apply the logit or probit analysis depending on the assumption regarding the distribution of the error term. Collier and Hoeffler (2004) based their analysis on the logit model; hence, to make comparison possible, the logit analysis will be conducted in this section to examine the hypothesis above. However, the main interest of this paper is to see the simultaneous impact of human capital

on economic growth and civil war. The two equations, the growth and civil war equations, will be estimated using the Seemingly Unrelated Regression (SUR) approach, and the logic of applying this approach will follow in the next section. Since the civil war equation in the SUR system equations in the following section is a linear probability model, I will also include the result of a linear probability model as a comparison of the logit model result in the Appendix. Since the estimates of the parameter coefficients from each approach, the logit and linear probability models, are not directly comparable, some transformation is required. Amemiya (1981) suggested a way to properly adjust the coefficients of the linear probability model to make direct comparison possible, and such adjustments will be made to compare the results.[3] This comparison will provide an idea about how large the difference in the magnitude of coefficient can be compared to the logit analysis when one interprets the result of the civil war equation in the SUR model, which is a linear probability model.

The logit analysis has been conducted to see how human capital, measured by average years in the total population, influences the risk of civil war onset. The result is presented in Table 1 and is compared to the results using different proxies of human capital including the male secondary enrolment rate. As Table 1 indicates, the magnitude of influence on the risk of civil war onset is much bigger when average schooling years in the total population is used in the analysis compared to when male secondary enrolment rate is used.

<Table 1>

In the endogenous growth theory, the presumption behind modelling technological progress or TFP (total factor productivity) as a function of human capital is that the higher the level of education the labour force has, the better in creating, implementing, and adopting new technologies, which in turn contributes to economic growth. Such ability may also indicate an ability to create, implement and adopt technologies that prevent from civil wars from occurring.

[3] For example, Amemiya (1981) suggested that when comparing the coefficients of probit, logit, and linear probability models, one should multiply the logit model coefficient by 1/16=0.625, and such transformation produces a closer approximation between the logistic distribution and the standard normal distribution function, which is the distribution function on which logit and probit models are based. He also suggested that to compare the coefficients between the linear probability model and the logit model, one should multiply the coefficients of logit model by 0.25 and add 0.5 for the constant term.

The current school enrolment rate is what determines future human capital stock – the higher the enrolment rate in the current period, the higher the accumulation of human capital in the future period. If the above hypothesis holds, low level of current school enrolment will result in less human capital stock in the future, which lowers the society's ability or accumulated technology to prevent civil wars from occurring in the future.

5. Estimation Model of Growth and Civil War Equations

The main interest of this study is to examine the simultaneous impact of human capital on growth and civil war to examine whether the level of human capital is an important factor in preventing the occurrence of civil wars as well as to contribute to economic growth simultaneously. Hence, the system of equations that includes the *growth equation* and the *civil war equation* can be modelled as follows:

$$\begin{aligned} \ln y_{i,t} - \ln y_{i,t-1} &= \beta_0^1 + \beta_1^1 y_{i,t-1} + \sum\nolimits_2 \beta_2^1 x_{2it}^1 + \beta_h^1 h_{it} + \eta_i^1 + \gamma_t^1 + v_{i,t}^1 \\ c^*_{it} &= \beta_0^2 + \sum\nolimits_n \beta_n^2 x_{nit}^2 + \beta_h^2 h_{it} + \eta_i^2 + \gamma_t^2 + v_{i,t}^2 \end{aligned} \qquad (5)$$

Note that c^*_{it}, η_i^1, γ_t^1, $v_{i,t}^1$, x_{2it}^1, x_{nit}^2 respectively represent a binary variable which takes a value of one if the country experienced a civil war during each five year period, country-specific effects of output growth, time-specific effects of output growth, (similarly defined for the variables with super-script 2), a random error term in growth equation (and for civil war equation with the super-script 2), vector of explanatory variables for growth equation including log of income share of physical capital and adjusted population growth, and the vector of explanatory variables for civil war onsets.

Note that the estimation of each equation, if estimated as a single equation by applying OLS, is based on the same observations. When each equation is estimated as a single equation estimation by using OLS, the error terms can be correlated. That is, two equations may be related through the correlation in the errors $v_{i,t}^1$ and $v_{i,t}^2$.

When the errors in different equations are correlated in a regression model, one can try to improve the efficiency of the estimation by taking these cross-equation correlations into

account. This approach was suggested by Zellner (1962) and called the Seemingly Unrelated Regression (SUR), which is also called joint generalized least squares (JGLS) or Zellner estimation. A SUR estimator is a generalized version of OLS for multi-equation systems in the sense that it assumes that all the regressors are independent variables as in OLS; however it uses the correlations among the errors in different equations to improve the regression estimates. The greater the correlation of the disturbances, the greater is the efficiency gain accruing to SUR, (or JGLS). (Greene, 2003) The system of equations (5) will be estimated by using a SUR approach. In the actual estimation step, the SUR estimation requires an initial OLS regression to compute residuals, which are used to estimate the cross-equation covariance matrix. The estimation results are presented in Section 6.

6. SUR Estimation Results

Table 2 presents the Seemingly Unrelated Regression result which was adopted to allow the estimation of output *growth* and *civil war* equations simultaneously while accounting for the correlated errors due to the fact that two models involve the same observations. This would lead to efficient estimates of the coefficients and standard errors. The estimates of the correlation coefficient between the errors of the *output growth* and *civil war* equations ranged from -0.282 to 0.285 at <1% significance level across models with different human capital measures, and the result of *Breusch-Pagan test* that examines whether the residuals from the two equations are independent shows that residuals were not independent in this model.

<Table 2>

The Growth Equation

Table 2 presents the estimation result of equation (5) in which the log of average years of schooling was used as a proxy for the human capital stock, or the level of human capital in the beginning of each period. I used four different measures of average years of schooling, namely average years of schooling in the total population aged above 25 (denoted as *tyr* in the Barro-Lee dataset), average years of schooling in the male population aged above 25 (*trym* in the Barro-Lee data set), average years of schooling in the total population aged

above 15 (denoted as *tyr15* in the Barro-Lee dataset), average years of schooling in the male population aged above 15 (*trym15* in the Barro-Lee data set).

While there is dispute over the effect of human capital on economic growth and studies have often failed to find a robust positive effect for educational attainment on output growth[4], the SUR estimation result in this study provides an indication of a positive effect of human capital on output growth. Two measures of the level of human capital, the average years of schooling in the total population aged above both 25 and 15 showed positive impacts on output growth, but this measure for the population above age 15 was only weakly significant (p-value=0.085). Moreover, the magnitude of the output effect of human capital was much bigger with the average years of schooling for aged above 25 (tyr), than the variable for above age 15 (tyr15).

If the reasoning in the endogenous growth theory literature to understand how human capital contributes to the economic growth actually holds – that the higher the level of education the labour force has, the higher the capability of the labour force to create, implement, and adopt new technologies, which in turn contributes to economic growth – then the level of accumulated knowledge and capability of labour force that matters to create, implement, and adopt new technologies to spur economic growth is rather post-secondary education than primary or secondary education. The average years of schooling of the total population over age 25 measures "how much education has actually been obtained" by those "who could have obtained, say, 15 years of schooling" if one chose to or was given the opportunity. By contrast, the average schooling years of the population above age 15 is a measure that contains noise: most importantly, a high proportion of the population aged 15 to 25 must be still in school and the knowledge being obtained while being enrolled in school is not associated with economic activities. If the advanced stock of knowledge that contributes to the economic growth can be obtained through higher education i.e. post-secondary education,

[4] Using panel data Islam (1995) finds that the human capital measure is not significant in the OLS levels regression and significant but negative when he uses a within groups estimator and provides a conclusion that the empirical test does not provide consistent support for the augmented Solow model. (Hoeffler, 1998)

the proportion of human capital of population being accumulated by the age group between 15 and 25, the group who is at school if post-secondary level education is being pursued by individuals, is rather potential or predicted knowledge stock that can spur economic growth in the future.

However, neither measure for the male population, namely the average years of schooling in the male population above age 25 (i.e. trym in the Barro-Lee dataset), and above age 15 (i.e. trym15 in the Barro-Lee dataset), was positively or significantly associated with output growth. These two measures were included because their correlations with *male secondary school enrolment,* a significant explanatory variable that is negatively associated with civil war risk, or the factor to decrease the likelihood the civil war onset, were very high (i.e.0.838 and 0835 for tyrm and tyrm15).

The coefficients of initial income and investment rate are signed consistently with the model and are significant at <1% level. Although the negative coefficients for population growth $\ln(n+g+\delta)$ were consistent with the model they were not statistically significant in the sample of this study.

Regarding the region-specific effects of growth, the negative growth effects of Sub-saharan Africa compared to the base-line country groups (North America, Europe and OECD countries that do not belong to either North America or Europe) were the biggest amongst all regional groups, as expected. Regarding the period-specific effect, the negative growth effect of the 80s compared to the baseline periods, the 60s and 70s, was statistically significant at the <1% significant level.

Civil War Equation

The main interest of this study is to see whether the level of human capital of the population, or the 'better absorptive capability of new technologies that can contribute to economic output,' can decrease how prone a given society is to civil wars.. Two human capital measures, average schooling years in the total population aged over 25 and aged over 15, were negatively associated with civil war onsets although the association was weakly significant, i.e. the p-values were 0.086 and 0.085, respectively.

Interestingly, however, while the growth effect of two human capital measures differ quite significantly in terms of their magnitude, in the civil war equation the level of human capital for the population over age 25 does not seem to perform better at decreasing the risk of civil wars than the level of population over age 15 does. This may indicate that although it is rather higher levels of education (i.e. post-secondary education) that spur the economic growth and the difference in the level of higher education explains the difference in economic growth across countries or across time period, the same level of advanced knowledge may not be required to decrease the risk of civil wars. Another interpretation could be that a certain level of human capital or education for the youth population, who is more vulnerable being the target group of rebel recruits in a civil war, helps decrease the civil war risks of a given society. The difference in the effects of human capital on economic growth and civil war onset may suggest that although the level of human capital influences both *output growth* and *civil war risks*, different levels or type of education or knowledge may influence each of them.

The association between the civil war onset and average schooling years in the male population aged over 25 and aged over 15 was not statistically significant in the SUR estimation. No regional-specific effects of the civil war equation were observed. Primary commodity exports (Sxp, at <1% level), a proxy for opportunities to rebel, are positively associated with civil war onset at a decreasing rate (Sxp Squared, at 5% level). Peace Duration measured in months after a previous civil war or a cold war period in the case of no previous civil war onset showed negative association with civil war onset as expected (at <1% level).

7. Summary and Conclusion

This study has examined the simultaneous impact of human capital on growth and civil war to see whether the level of human capital is an important factor in preventing the occurrence of civil wars as well as to contribute to economic growth. The empirical result is based on panel data consisting of 107 countries observed at five-year intervals from 1960 to 1995.

Before answering the main question of the simultaneous effect of human capital on economic growth and civil war onset, this study first examined whether the initial level of *human capital* of a population can help to prevent civil war onset by applying single equation logit analysis to provide a comparison to the existing literature in the economics of conflict, such as Collier and Hoeffler (2004). The findings show that the level of initial human capital is a significant factor that substantially decreases the risk of civil war onset.

Then, keeping this possibility of contemporaneous cross-equation error correlation in two equations in mind, a system of two equations is simultaneously estimated through a seemingly unrelated regression (SUR) method to improve the efficiency of the estimation by taking these cross-equation correlations into account. The result of the SUR estimation suggests that level of human capital is an important factor of output growth and it is also negatively associated with civil war onset.

However, the estimation result also leaves a hypothesis of further research: the fact that the average years of schooling of total population over age 25 has a bigger effect on output growth than the measure for the population over age 15 does, while it does not in terms of influence to civil war onset, may imply that although level of human capital influence both *output growth* and *civil war risks*, different levels or type of education or knowledge influence each of them. Another interesting question is whether there is a certain level of human capital or knowledge stock that can effectively prevent civil wars from occurring and if there is, what that level is. The negative association between the 'initial stock of human capital' and civil war onset can justify the promotion of policy that tries to educate youth of developing countries that are more vulnerable to civil war risks. In this regards, the World Bank's *education for all* policy of the MDGs (Millennium Development Goals) has significant potential to reduce the risk of civil wars in beneficiary countries if the primary education is sufficient in preventing civil wars effectively. If more that primary education is required to acquire the sufficient level of knowledge stock to prevent civil war risks, however, the education for all policy goals of the MDGs may not be effective at least in terms of preventing civil wars.

The importance of promoting such policy comes from the fact that 'human capital investment' or 'accumulation of human capital' are individual decision variables that are

determined by the circumstances surrounding individuals, opportunity costs, expected returns to education, and so on. Hence, releasing the constraints of education investment facing the population through supports, as well as making a certain level of education (say, up to secondary education) mandatory, may effectively help prevent civil wars from occurring.

There are a number of short-comings of this study, which is a work in progress, including the data and methodological issues. First and foremost, it has significant room to improve the data in terms of sample size. The sample size used in the estimation was very small (688 observations) due to a lot of missing values in the variables in the civil war equation as well as the education (Barro-Lee) data set. With regards to the variables in the civil war equation, recent studies have used a much improved data set (Collier and Hoeffler, 2006; Fearon, 2005) by updating the series to more recent years as well as by applying multiple imputation technique to replace missing values. Hence, the update of the data set used in the study can be done and is crucial for improving the information used in the analysis.

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<Table 1 > Human Capital Measure and Conflict Risk: Logit Analysis

Dependent Variable: Civil War Onset				
	(1) male secondary school enrolment (sec)	*(2) Average schooling yrs in the total population aged above 25 (tyr)*	*(3) Average schooling yrs in the male population aged above 25 (tyrm)*	*(4) Average schooling yrs in the total population aged above 15 (tyr15)*
Human Capital Measure	-0.026	-0.342	-0.313	-0.350
	(0.011)**	(0.113)***	(0.106)***	(0.111)***
GDP per Capita Growth (t-1)	-0.160	-0.144	-0.143	-0.141
	(0.054)**	(0.050)***	(0.050)***	(0.050)***
Primary Commodity Exports (sxp)	14.386	12.191	12.344	12.496
	(5.846)**	(5.305)**	(5.289)**	(5.339)**
Sxp squared	-19.310	-17.972	-17.953	-17.953
	(11.392)*	(10.317)*	(10.260)*	(10.377)*
Social Fractionalisation	-0.00012	-0.00009	-0.00006	-0.00009
	(0.00010)	(0.00009)	(0.000090)	(0.00009)
Ethnic Dominance	0.703	0.422	0.424	0.432
	(0.409)*	(0.372)	(0.373)	(0.373)
Peace Duration	-0.004	-0.004	-0.004	-0.004
	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Ln Population	0.644	0.408	0.443	0.424
	(0.176)***	(0.149)***	(0.153)***	(0.152)***
Constant	-12.391	-8.107	-8.630	-8.254
	(3.263)***	(2.781)***	(2.810)***	(2.808)***
Observations	585	625	624	616
Log Likelihood	-99.76	-112.02	-112.56	-111.67

Note. All regressors include a constant. Standard errors are in parenthesis. *, **, and *** indicate the level of significance at 10%, 5%, and 1% level, respectively.

<Table 2> SUR Estimation Results: Growth and Civil War Equations

Growth equation

	ltyr Ln (Avg. schooling years in the total population aged over 25)	*Ltyrm* Ln (Avg. schooling years in the male population aged over 25)	*ltyr15* Ln (Avg. schooling years in the total population aged over 15)	*ltyrm15* Ln (Avg. schooling years in the male population aged over 15)
Human Capital Ln(hit)	0.013	0.009	0.009	0.005
	0.005**	0.006	0.006*	0.006
Ln(Yi,t-1)	-0.029	-0.027	-0.026	-0.024
	0.005***	0.005***	0.005***	0.005***
$\ln(n+g+\delta)$	-0.018	-0.021	-0.022	-0.023
	0.018	0.018	0.018	0.018
Ln(sit)	0.031	0.032	0.030	0.031
	0.005***	0.005***	0.005***	0.005***
Dssa	-0.056	-0.058	-0.055	-0.057
	0.012***	0.012***	0.012***	0.012***
Dlatin	-0.024	-0.023	-0.022	-0.021
	0.009***	0.009***	0.009**	0.009**
Dsasia	-0.027	-0.031	-0.026	-0.029
	0.016*	0.016*	0.016	0.016*
Deasia	0.022	0.022	0.025	0.025
	0.013*	0.013*	0.013**	0.013*
Dmena	-0.027	-0.029	-0.026	-0.027
	0.012**	0.012**	0.012**	0.012**
D80	-0.023	-0.021	-0.022	-0.021
	0.006***	0.007***	0.006***	0.006***
D90	0.006	0.008	0.011	0.012
	0.009	0.009	0.008	0.008
_cons	0.160	0.135	0.128	0.112

	0.064**	0.063**	0.062**	0.061*
R-square	0.207	0.203	0.21	0.198
Breusch-Pagan test of independence	chi2(1) = 54.352 Pr = 0.0000	chi2(1) = 54.501 Pr = 0.0000	chi2(1) = 55.594 Pr = 0.0000	chi2(1) = 55.858 Pr = 0.0000

Note. All regressors include a constant. Standard errors are in parenthesis. *, **, and *** indicate the level of significance at 10%, 5%, and 1% level, respectively.

<Table 2> Continued

Civil War Equation

	ltyr Ln (Avg. schooling years in the total population aged over 25)	*Ltyrm* Ln (Avg. schooling years in the male population aged over 25)	*ltyr15* Ln (Avg. schooling years in the total population aged over 15)	*ltyrm15* Ln (Avg. schooling years in the male population aged over 15)
Human Capital Ln(hit)	-0.026	-0.027	-0.029	-0.028
	(0.015)*	(0.017)	(0.017)*	(0.019)
Primary Commodity Exports (sxp)	0.364	0.364	0.439	0.438
	(0.165)**	(0.166)**	(0.165)***	(0.165)***
Sxp squared	-0.458	-0.460	-0.528	-0.529
	(0.219)**	(0.219)**	(0.217)**	(0.218)**
Social Fractionalisation	-0.000004	-0.000003	-0.000005	-0.000005
	(0.000007)	(0.000007)	(0.000007)	(0.000007)
Ethnic Dominance	0.026	0.025	0.030	0.029
	(0.018)	(0.018)	(0.018)*	(0.018)
Peace Duration	-0.000337	-0.000339	-0.000327	-0.000328
	(0.000070)***	(0.000070)***	(0.000069)***	(0.000069)***
Ln Population	0.010	0.010	0.014	0.014
	(0.007)	(0.007)	(0.007)**	(0.007)**
Mount	0.000149	0.000151	0.000205	0.000
	(0.000447)	(0.000448)	(0.000443)	(0.000)
Dssa	0.018	0.024	0.020	0.027
	(0.041)	(0.041)	(0.041)	(0.041)
Dlatin	-0.005	-0.005	-0.005	-0.004
	(0.026)	(0.027)	(0.026)	(0.027)
Dsasia	0.049	0.057	0.047	0.056

	(0.054)	(0.053)	(0.053)	(0.052)
Deasia	-0.036	-0.033	-0.037	-0.034
	(0.043)	(0.043)	(0.043)	(0.043)
dmena	0.058	0.064	0.058	0.064
	(0.038)	(0.037)*	(0.037)	(0.037)*
d80	0.054	0.053	0.050	0.049
	(0.024)**	(0.024)**	(0.024)**	(0.024)**
d90	0.057	0.055	0.052	0.050
	(0.032)*	(0.032)*	(0.031)*	(0.031)
_cons	-0.019	-0.019	-0.088	-0.091
	(0.118)	(0.118)	(0.120)	(0.121)
Adj. R-square	0.087	0.086	0.087	0.086
No. of observation	684	683	688	688
Breusch-Pagan test of independence	chi2(1) = 54.352 Pr = 0.0000	chi2(1) = 54.501 Pr = 0.0000	chi2(1) = 55.594 Pr = 0.0000	chi2(1) = 55.858 Pr = 0.0000

Note. All regressors include a constant. Standard errors are in parenthesis. *, **, and *** indicate the level of significance at 10%, 5%, and 1% level, respectively.

Appendix Comparison of the logit and linear probability models

Dependent Variable: Civil War Onset

	Logit	*Blogit+0.25*	*Linear Probability*
Secondary male enrolment	-0.026	-0.007	-0.0005
	(-2.820)***		(-1.410)
GDP per Capita Growth (t-1)	-0.143	-0.036	-0.010
	(-3.210)***		(-3.790)***
Primary Commodity Exports (sxp)	14.839	3.710	0.376
	(2.870)***		(2.430)**
Sxp squared	-22.032	-5.508	-0.386
	(-2.160)**		(-1.850)*
Social Fractionalisation	-0.00014	-0.00004	-0.00001
	(-1.700)*		(-1.110)
Ethnic Dominance	0.537	0.134	0.016
	(1.490)		(0.890)
Peace Duration	-0.004	-0.001	-0.0003
	(-3.300)***		(-4.330)***
Ln Population	0.610	0.153	0.023
	(4.100)***		(3.710)***
Constant	-11.887	-2.472	-0.203
	(-4.420)***		(-1.870)*

Notes.

1. Z values are in parenthesis. *, **, and *** indicate the level of significance at 10%, 5%, and 1% level, respectively.
2. In the third column, “0.25*blogit+0.5” is used for calculation for the constant term.

Appendix (Cont'd)

Dependent Variable: Civil War Onset

	Logit	*0.25*blogit*	*Linear probability*
Average schooling yrs in the total population aged above 25 (tyr)	-0.317	-0.079	-0.008
	(-2.820***)		(-2.080**)
GDP per Capita Growth (t-1)	-0.158	-0.039	-0.011
	(-3.110***)		(-3.940***)
Primary Commodity Exports (sxp)	11.694	2.923	0.329
	(2.210**)		(1.900*)
Sxp squared	-16.757	-4.189	-0.343
	(-1.650*)		(-1.500)
Social Fractionalisation	-0.00008	-0.00002	-0.000004
	(-0.870)		(-0.650)
Ethnic Dominance	0.306	0.076	0.014
	(0.800)		(0.670)
Peace Duration	-0.004	-0.001	0.000
	(-2.940***)		(-3.650***)
Ln Population	0.388	0.097	0.017
	(2.560*)		(2.400**)
Constant	-7.857	-1.464	-0.092
	(-2.800***)		(-0.740)

Notes.

1.Z values are in parenthesis. *, **, and *** indicate the level of significance at 10%, 5%, and 1% level, respectively.
2. In the third column, "0.25*blogit+0.5" is used for calculation for the constant term.

Appendix (Cont'd)

Dependent Variable: Civil War Onset

	Logit	*Blogit+0.25*	*Linear Probability*
Average schooling yrs in the total population aged above 15 (tyr15)	*-0.321*	*-0.080*	*-0.010*
	(-2.870)***		(-2.360)**
GDP per Capita Growth (t-1)	-0.151	-0.038	-0.011
	(-3.040)***		(-3.740)***
Primary Commodity Exports (sxp)	12.503	3.126	0.416
	(2.360)**		(2.280)**
Sxp squared	-17.399	-4.350	-0.420
	(-1.700)*		(-1.770)*
Social Fractionalisation	-0.00009	-0.00002	-0.00001
	(-0.990)		(-0.820)
Ethnic Dominance	0.357	0.089	0.020
	(0.940)		(0.890)
Peace Duration	-0.004	-0.001	-0.0002
	(-2.890)***		(-2.750)***
Ln Population	0.429	0.107	0.021
	(2.850)***		(2.710)***
Constant	-8.524	-1.631	-0.179
	(-3.080)***		(-1.310)

Note.

1. Z values are in parenthesis. *, **, and *** indicate the level of significance at 10%, 5%, and 1% level, respectively.
2. In the third column, "0.25*blogit+0.5" is used for calculation for the constant term.

Appendix (Cont'd)

Dependent Variable: Civil War Onset

	Logit	*Blogit+0.25*	*Linear Probability*
Average schooling yrs in the male population aged above 25 (tyrm)	*-0.284*	*-0.071*	*-0.008*
	(-2.680)***		(-1.940)**
GDP per Capita Growth (t-1)	-0.157	-0.039	-0.011
	(-3.130)***		(-3.900)***
Primary Commodity Exports (sxp)	11.815	2.954	0.339
	(2.240)**		(1.930)*
Sxp squared	-16.724	-4.181	-0.352
	(-1.660)*		(-1.520)
Social Fractionalisation	-0.00006	-0.00001	-0.000003
	(-0.630)		(-0.510)
Ethnic Dominance	0.306	0.077	0.013
	(0.800)		(0.640)
Peace Duration	-0.004	-0.001	-0.0002
	(-3.010)***		(-3.540)***
Ln Population	0.418	0.104	0.018
	(2.710)***		(2.450)**
Constant	-8.307	-1.577	-0.106
	(-2.930)***		(-0.840)

Notes.

1. Z values are in parenthesis. *, **, and *** indicate the level of significance at 10%, 5%, and 1% level, respectively.
2. In the third column, "0.25*blogit+0.5" is used for calculation for the constant term.