Does Concentration of Wealth Affect Growth?
Preliminary Results of a Cross-National Analysis

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Abstract: This paper presents a refinement of Deininger and Squire's work on the relationship between the concentration of wealth and subsequent economic growth. Data on 60 countries taken from several well-established time series are analyzed using a log-linear regression model derived from a modified Solow output function. The primary results suggest a negative correlation between concentration of wealth and subsequent economic growth; specifically, a one standard deviation decline in wealth concentration would be expected to raise a country's subsequent annual growth rate by 0.6%. Unfortunately, the results do not reach statistical significance at the 5% level. Several modifications underway as part of the final dissertation research are then outlined.

I. Introduction

The purpose of this paper is to test for a relationship between the concentration of wealth within countries and their subsequent economic output. The most prominent obstacle to research involving the distribution of assets is simply the rarity of data. Decades of effort by international agencies and academics have produced cross-national datasets on topics ranging from education to capital stocks, but only recently has attention been turned to wealth concentration, such as the recent initiation of a project by the Luxembourg Income Study Project (Brandolini and Smeeding, 2005). In that context, the primary contribution of this paper is its use of a novel dataset, the land holdings data of the World Census of Agriculture, as a measure of wealth concentration. In this respect, this paper follows in the footsteps of Klaus Deininger and Lyn Squire's work with the dataset in their article "New ways of looking at old issues: inequality and growth" (1998). Their results suggested that there was a strong effect of initial asset inequality on subsequent growth, a conclusion that has been cited somewhat frequently in subsequent literature. However, their model was rather primitive relative to standard approaches to the topic, and thus it seemed that it would be productive to apply the data they had identified to a more sophisticated model of growth. So, this paper attempts to marry an underutilized dataset to the standard approaches of growth theory.

This leaves the question of why the existence of a relationship between wealth concentration and growth is worthy of examination. The main reason is that if concentration of wealth aids growth, then equity and growth are fundamentally opposed, with efforts to spread prosperity tending to compromise growth; if instead concentration hinders growth, then efforts to increase equity can simultaneously aid in expansion of the economy. Since disagreements over how to balance poverty alleviation with development emerge in policy debates at every level from local to international, establishing the existence and nature of any relationship could provide significant insight into which policies best support economic growth.

The rest of this paper presents results from a preliminary analysis of the relationship between the concentration of wealth and economic development. Section II provides a brief review of the current state of growth theory, while Section III is an overview of proposed mechanisms for how wealth concentration might hinder or aid economic growth. Then, Section IV will outline the methodology used in the analysis, in particular describing the datasets used and the regression model, and Section V will present the results of the regressions. Finally, Section VI summarizes the results and ends with a description of refinements which are currently in progress and excluded due to time constraints associated with the timing of the job market.

II. A Brief Overview of Growth Theory

Robert Solow and Neoclassical Growth Theory

The mainstream of growth theory today was largely defined by Robert Solow in 1956. In his article "A contribution to the theory of economic growth", Solow challenged the dominant Harrod-Domar model, which assumed that economic output was defined by fixed proportions between labor and capital. Solow showed that by relaxing this assumption to allow the standard neoclassical substitution between inputs, the key conclusions of the Harrod-Domar model (concerning inherent instability of growth rates) melted away. As it turns out, the two primary consequences of the article for the modern approach to economic growth are, respectively, ironic and incidental, given Solow's focus.

The ironic consequence is that the Cobb-Douglas functional form of aggregate output, $Y=F(K,L)=K^{\alpha}L^{\beta}$, which was one of Solow's primary tools in his article, dominates in most discussions of growth. The irony stems from the fact that Solow's article actually presents a variety of functional forms, precisely because his central point was that the assumptions implicit within any functional form for output can unintentionally determine the conclusions reached by the model. The incidental consequence is the introduction of technical progress, A, as a multiplicative term accompanying the output function: $Y=A(t)F(K,L)=e^{gt}K^{\alpha}L^{\beta}$. This was just one of several modifications that Solow made to his basic models as a way of further demonstrating the importance of model assumptions to the final conclusions reached. However, unlike the other modifications in the paper, this one has been incorporated into much of the work in the field.

It is, of course, an oversimplification to place either of these consequences directly at the foot of this one paper. However, Solow's work in the mid-50s did much to define the field today. In addition to "A contribution", his 1957 paper "Technical change and the aggregate production function" did much to reinforce these two influences, applying a Cobb-Douglas model with neutral technological change to empirical data available at the time. However, that paper also made an observation that has much to do with the other major approach to the field: he ascribed nearly 90% of the increase in US output between 1909 and 1949 to "technical change".

Technological Progress and New Growth Theory

The "Solow model" has been used widely in subsequent decades of research into growth, but many researchers have pointed out flaws in the model. The core complaint is that model's only source of cross-country variation in output is variation in the quantity of inputs. As David Romer points out in his (quite literally) textbook summary of the debate, empirical estimates of the model's parameters seem to predict much wider variation in capital stocks than exist in the real world. For example, given two countries with per capita GDPs differing by a factor of 10 (not unrealistic for the real world), the per capita capital stocks of the two countries would have to differ by a factor of 1000 to account for the observed output differences (since typical estimates of the exponent on the capital term in the model are around 1/3).

Thus, the "New Growth Theory" movement has emerged to argue that observed global differences in output must be largely attributable to factors other than stocks of labor and capital. Much of their work has gone into examining functional forms for the $A(t)$ factor, or "Solow residual", beyond simple exponential growth. The most basic difficulty is that theoretically anything could be (and has been) thrown into the mix, so the competing proposals are numerous. Nevertheless, it seems that there is more going on in determining economic output than can be accounted for without going into greater detail in characterizing the Solow residual.

This does not mean that "classical" growth theory has been consigned to the scrapheap. Among other things, the growing prominence of human capital theory has had an impact, providing another somewhat readily measured element that can be added to the basic Cobb-Douglas structure without requiring conceptually messy mucking-about with the residual. In their 1992 paper "A contribution to the empirics of economic growth," Gregory Mankiw, David Romer and David N. Weil found that by introducing a human capital term to the Cobb-Douglas component of the model, they could boost the amount of variation in output explained by the standard Solow model from 50% to 80%.

With this as context, this paper might be characterized as part of the New Growth project, since it focuses on a modification of the Solow residual term. However, the innovation of adding human capital data is adopted as well. Ultimately, the distinction between the classic Solow model and New Growth theory is, as usual, a case of unnecessary polarization of two compatible approaches, and I choose not to choose between them.

III. Mechanics of the Wealth Concentration/Growth Relationship

Moving on to the treatment of the wealth concentration/growth linkage in the literature, the most important observation is that there is no consensus answer to the basic question of whether wealth concentration is good or bad for growth; each outcome is represented by relatively intuitive models (as well as more baroque ones, of course). Thus, the primary insight that can be drawn from the literature is how one might structure an empirical model to capture any influence that may exist. The rest of this section provides brief descriptions of several different possible relationships, and how an empirical model could be constructed to test for the suggested effect.

Differential Savings Rates

The simplest argument for a positive effect of wealth concentration on growth stems from the recognition that the marginal propensity to save tends to rise with wealth. Under the standard Solow model, the rate of growth is determined by the growth rate of inputs, and since under normal assumptions gross investment equals savings, a greater degree of concentration of wealth will lead to more rapid investment, and consequently higher rates of economic growth. An empirical model to capture this effect would need to make investment a function of the concentration of wealth. While this is not done in the empirical analysis that follows, the correlation matrix in Chapter IV shows little evidence for such a relationship, and in fact shows a negative (though small) correlation. Expanding the definition of investment, correlations with growth rates in human capital are positive, but still small.

Wealth Constraints and Diminished Productivity of Investment

A number of models examine how the interaction of wealth constraints on investment with patterns of distribution can lead to reduced results from investment in the aggregate. As one example, Philippe Aghion and Patrick Bolton (1997) lay out a model where individuals have different endowments of wealth w, and have the choice of undertaking risky entrepreneurial activity with possible return r, the success of which has probability equal to the level of costly effort p, and requiring a fixed quantity of capital (normalized to 1). If individuals have the ability to borrow the remainder with a repayment of $\rho(w)$, but the liability of borrowers is limited to their own wealth stock (i.e. contracts in the lending market are incomplete, leading to moral hazard), then entrepreneurs will choose their level of effort p according to

$$\max_{p}\{pr - p(1-w)\rho(w) - C(p)\} \Rightarrow p(w) = a(1-(1-w)\frac{\rho(w)}{r})$$

where a represents the first-best effort (exerted by individuals with w>=1), and $C(p) = \frac{rp^2}{2a}$, the quadratic cost function of effort. The equilibrium rate of return A_t>=1 is then determined by equating all expected returns from loans

$$A_t = p(w)\rho(w) = a\rho(w)(1-(1-w)\frac{\rho(w)}{r})$$

which by the quadratic theorem means that $\rho'(w)<0$, and thus $p'(w)>0$. So, effort increases with the initial endowment of wealth, and those who borrow exert less than first-best levels of effort. Aghion and Bolton then go on to show that over the course of successive intervals, this disincentive to effort by borrowers means that economies with higher levels of initial wealth concentration display slower growth.

Pranab Bardhan, Samuel Bowles and Herbert Gintis (1999) present a similar model with projects of variable capital requirements (with a minimum project size) and quality (i.e. expected profitability). They are able to show that because of the moral hazard associated with borrowing, lower quality projects undertaken by individuals with wealth sufficient to self-finance them will go forward in preference to higher quality projects that require borrowing by lower wealth individuals. As a result, wealth concentration is associated with lower returns to aggregate investment, and thus lower rates of growth.

Modifying a simple growth model to test for this type of relationship is a little tricky. Testing the proposition "Concentration of wealth is negatively correlated with growth" can be done with a Solow-style model by simply introducing the distributional measure as a shift in the baseline "technical" growth rate (i.e. replacing gt in the Solow residual with $(g_0 + g_1X)t$). Alternately, since these predicted effects of the wealth concentration are felt as reduced returns to aggregate investment, incorporating the distributional measure as a shift term in the elasticity of output with respect to capital (e.g. replacing α in the standard Solow specification with $\alpha_0 + \alpha_1 X$) might work as well. However, capturing the dependence of the disincentive on the credit market imperfections would require adding some sort of measure of the completeness of credit markets and interacting it with the distributional measure, a significant complication compared to the simple structural alterations above.

Wealth Constraints and Educational Investment

A somewhat more complex story is told by Cecilia Garcia-Penalosa in "The paradox of education or the good side of inequality" (1995). She develops a model with skilled and unskilled labor where the cost of education to skilled status is derived from an equilibrium wage model with all skilled labor (divided into teachers, students, researchers and skilled labor) paid the same amount, and then introduces an imperfect credit market for human capital investment, reducing opportunities for education to less than the optimal amount based on a wealth constraint. In the end, she shows that given a two-tailed distribution of wealth, the effect of wealth concentration (i.e. the spread of the distribution) on the rate of investment in education will depend upon the cost of education relative to the mean wealth level: if the cost of education is less than mean wealth, an increase in wealth concentration (i.e. a widened spread in the distribution) will decrease the number of individuals seeking education, as the tail of the distribution below the training cost lengthens; if, instead, the cost of education is greater than mean wealth, an increase in wealth concentration results in an increase in the number of individuals seeking education, as the tail of the distribution greater than the training cost lengthens. Since the derived growth rate of the economy in this model is a function of the quantity of skilled labor, higher wealth concentration is predicted to increase growth in poor countries and decrease it in rich countries.

Stated simply, this suggests that the relationship between wealth concentration and growth may be positive or negative based upon individual national characteristics. Testing for this type of relationship seems to call for adding multiplicative terms to the model to control for interactions between the distributional measure and other factors. In this particular case, the "other factor" would ideally be the ratio of educational costs and average household net worth, neither of which is covered by commonly available international datasets. Even so, just interacting a basic measure of relative national prosperity (e.g. per capita GDP) with wealth concentration might be a worthwhile step to control for differential effects on poor and wealthy countries.

Social Tension and Government Action

One common idea that emerges in the literature is that concentration of wealth disadvantages the median political actor in a country, which leads to political support for redistributive taxation. Since this is generally assumed to reduce the return to investment, the end result is lower investment rates (along with capital flight, etc.) and subsequently reduced economic growth. Ronald Benabou (1996) develops a model of this sort with an additional feature: a measure of how far from the median voter the political decision point lies. He defines p as the pth percentile of wealth holding, so if the political balance point lies at $p<1/2$, then government policies are biased towards the less well-off, due to populist ideology, strong unions, or other forces, while a $p>1/2$ represents governance biased towards larger capital-holders due to vote buying, wealth-restricted suffrage, or other influences. His prediction is that the growth effects of wealth concentration, while consistently negative, are less extreme the more biased the balance point of governance is towards the holders of capital. This is on top of a prediction that growth rates will be higher in general the more biased governance is towards holders of capital, due to reduced pressure for redistributive taxation.

These predictions clearly suggest that political characteristics of a country may alter the magnitude of growth effects due to wealth concentration. The difficulty of specifically testing Benabou's predictions falls again into the category of data availability: even limiting attention to tax rates, cross-national time series data is difficult to come by, particularly for countries outside the OECD. In addition, the political bias in Benabou's model was measured by redistributive taxation, not taxation in general; presumably massive spending on military expansion or infrastructure boondoggles do not represent the same thing in terms of political pressure as public spending on education or transfer programs. However, to the extent that the overarching question is one of security of property rights, information on political freedom may still be useful as a control for the growth effects of potential expropriation.

IV. Methodology

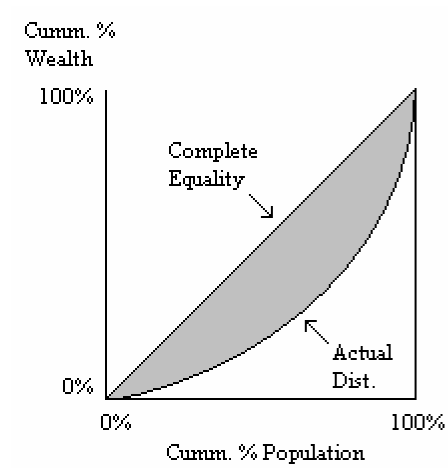
Model

In accordance with the standard practices in this area, I begin with a simple Cobb-Douglas output model including capital, labor and human capital, along with the "Solow residual"; the classic simple exponential form is used as the starting point here. In addition, for this analysis a narrow focus will be taken on the role of wealth concentration as a shift term in the Solow residual. Finally, rather than make any assumptions about returns to scale, the exponents on the input terms will be left independent. Thus, the initial model takes the form $Y = A_o e^{(r_o + r_1 G)t} K^{\alpha} L^{\beta} H^{\gamma}$, where G represents the initial Gini coefficient of wealth concentration (see below). Converted to a growth model (using the % prefix to represent growth rates) gives

$\%Y = (r_0 + r_1 G)dt + \alpha(\%K) + \beta(\%L) + \gamma(\%H)$; in this context, dt represents the length of the interval over which the growth rates were measured, and the coefficient r_1 represents the marginal effect of wealth concentration on the baseline (i.e. "technical") annual growth rate r_0. The expectation is that all of the estimated coefficients except for r_1 will be positive, the sign of r_1 (and whether it differs from zero) being the question of interest.

Gini Coefficient

The Gini coefficient is a very common measure of the concentration of income, but can be calculated for any good where the size distribution of shares is known. As illustrated by the accompanying image, a Gini coefficient is derived from the area between the cumulative distribution curve for the good, and the 45-degree line that represents perfect equality of distribution. Doubling the area between the two curves results in the Gini coefficient of concentration for the good in question, ranging between 0 (for perfect equality) and 1 (for a case where all of the good is in the hands of one individual).



It is generally true that data on distribution is discontinuous, and as such the cumulative distribution curve must be approximated by some means, since its functional form is unknown. Some work has been done on estimating the parameters of the Lorenz curve that characterizes the cumulative distribution, such as Kakwani and Podder's (1976) innovation of using a CES function defined relative to the equality line to estimate a functional form for the actual distribution. However, such methods generate Gini coefficient estimates in excess of 1 for countries with the highest levels of concentration, so this paper uses the parallelogram method for estimating the area under the distribution curve (for further discussion of this method, see FAO, 1984 (p. 16)).

Data Sources

With the model laid out, there follows a brief overview of the data sources used to operationalize the variables in the model. In each case the name of the source is followed by a parenthetical list of which variables are derived from that source, followed by a discussion of the relative strengths and weaknesses of the source.

World Census of Agriculture (*G*): It is an unfortunate and unavoidable fact that the limits of available data weigh heavily on research into the effects of wealth concentration. The ideal data set for the subject would contain yearly information on the size distribution of all asset holdings by household, on a country-by-country basis, extending back several decades into the past. Unfortunately, there is currently no cross-national dataset that fulfills all of these criteria. The current situation is that the only well-established cross-national dataset on the distribution of assets has been collected as part of the World Census of Agriculture, a project of the United Nation's Food and Agriculture Organization. While this dataset has the advantages of stretching back to roughly 1950 for the earliest reports, and covering nearly 100 countries, both developed and developing, it suffers from two limitations, one that is a central consideration when interpreting the results of this research, and one which merely limits the types of analyses which may be performed.

The primary limitation is that the data covers only the distribution of agricultural land, rather than the distribution of all assets. This obviously means that the value of the results from this research will depend on the answer to the question "does the pattern of distribution of agricultural land in a country mirror or correlate with the pattern of distribution of assets in the country?", an issue which will not be discussed in this paper, but which will be addressed in the final dissertation. The other limitation is that rather than being an annual data set, the World Census of Agriculture is a compilation of decadal surveys performed by each participating country. However, referring back to the model, one can see that G is used as a stable term covering interval dt, and as such the only real loss in data quality associated with the decadal nature of the data is that the start dates of the intervals will not match, due to the varied timing of the surveys across countries, and the inconsistent participation by different countries. While even this limited impact is less than ideal, the consequences can at least be explored directly by restricting attention to specific decades, and seeing if the parameter estimates shift dramatically based on the intervals examined.

Penn World Table (Y): Economic growth is calculated based on national GDP values, taken from the annual data in version 6.1 of the Center for International Comparisons' Penn World Table. The table initially reported the GDP data in constant dollar per-capita terms; conversion to aggregate totals was accomplished by multiplying the initial values by the population totals also reported in the PWT.

Easterly and Levine (K, L): Measures of two of the production inputs come from the dataset used in Easterly and Levine's 2001 article "It's not factor accumulation: stylized facts and growth models" (and distributed by New York University under the label "Micro Time Series"). Specifically, the capital stock measure comes from their estimates derived from aggregate investment figures, while the labor supply measure comes from their data on number of workers. The capital stock data was originally reported on a per-worker basis, and was converted to totals by multiplying the per-worker value by the number of workers.

Barro and Lee (*H*): Two different measures of human capital are taken from the semi-decadal dataset used by Barro and Lee in their 2000 paper "International data on educational attainment: updates and implications". The specific measures are total number of secondary education graduates aged 25 or older, and total years of school completed by individuals aged 25 or older. The original data was reported in fractional terms (i.e. percentage of graduates and average years completed), and was converted to totals through multiplication by the total population aged 25 or older for each year (which was also reported in the dataset). Other populations were also broken out in the dataset (i.e. aged 15 or older; females only for both age groups), but the 25 and over group was used because the graduation percentages for the younger populations were so low for many countries (i.e. 0.1% or even 0%) that rounding error could swamp actual changes between measurement periods. Data on both graduates and years completed were retained in order to test the results for basic robustness.

Modifications to Data

Due to the nature of the datasets being used, a few adjustments to the raw data were needed in order to suit it to the analytical scheme. The modifications required to convert percentages and per-capita values into gross amounts were mentioned above. In addition, there were a large number of countries for which decades of data were initially useless because of single-year mismatches between wealth data collections and the first year of reported data in other data series. Thankfully, the Gini coefficients generated from the World Census of Agriculture reports were remarkably stable across decades for the vast majority of countries, rarely changing by more than a few hundredths over multiple decades. As such, for the countries where a single year mismatch existed between the Gini coefficient data and other datasets, the Gini coefficient for year *t* was proxied for by the Gini coefficient for year *t*-1. This affected the following countries, a total of 24: Australia, Bangladesh, Belgium, Costa Rica, Denmark, Dominican Republic, El Salvador, Finland, Guatemala, Iraq, Ireland, Japan, Rep. of Korea, Lesotho, Luxembourg, Netherlands, New Zealand, Norway, Pakistan, Panama, Senegal, United Kingdom, United States, Yugoslavia.

Finally, because Barro and Lee's data on secondary school graduates was only reported for every fifth year, it was necessary to interpolate values for the missing years in order to be able to calculate growth rates between arbitrary years. This was done by calculating the annual growth rate during each five-year interval, and then applying the appropriate compounding to the initial value to estimate the values for the missing years.

Once the annual data was finalized, a custom program was used to calculate all possible growth intervals from each base year that had Gini coefficient data. For purposes of this initial analysis, only the longest interval that contained all of the desired variables was used for each country. Other selection criteria will be discussed at the end of this paper.

Summary Statistics and Correlations

To provide a sense of the raw data (if growth rates compiled from annual data can be considered "raw"), the following table summarizes the primary variables in the dataset. In addition to standard summary variables, a brief definition of each variable is provided.

60 Total Observations (one observation per country)					
Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**Definition**
interval (*dt*)	27.633	6.2841	9	40	Growth period observed, in years
year	1962.2	6.1603	1950	1981	Start year of growth period
rgdpltot (%*Y*)	2.4863	2.1737	-0.02644	12.581	Growth of GDP over observed period
workers (%*L*)	0.81666	0.52723	0.08372	2.5499	Growth in number of workers over observed period
agcap (%*K*)	4.4992	5.1982	0.645007	26.902	Growth in capital stock over observed period
hsgrads (%*H*)	7.8993	7.0743	0.197509	25.682	Growth in number of secondary school graduates over observed period
totschl (alt. %*H*)	3.4780	5.1291	0.2647859	35.131	Growth in total years of schooling over observed period
gini (*G*)	0.6635	0.15818	0.35	0.94	Gini coefficient at beginning of period
intgini (*G***dt*)	18.452	6.5991	7.03	34.4	Product of gini and interval

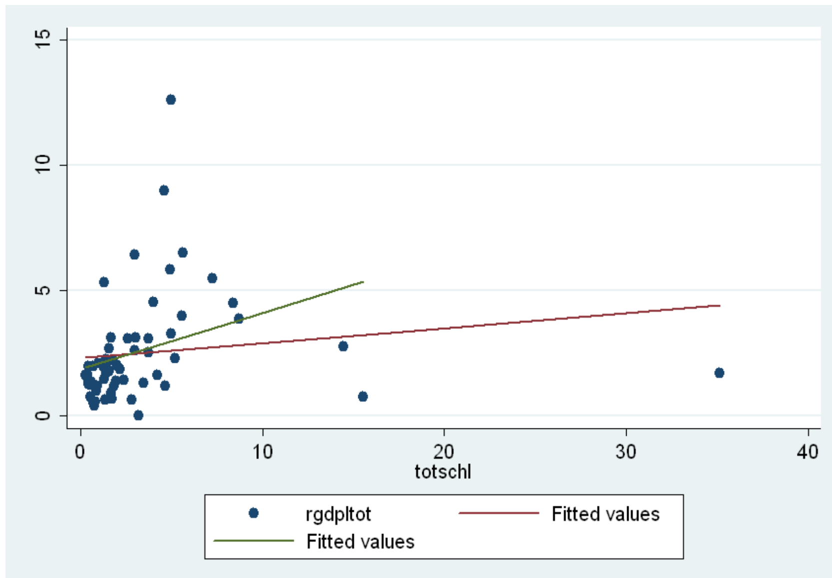
The table contains a few details of note. First, the intervals covered for individual countries range from 9 to 40 years. In most cases, this is because of limited coverage of Gini coefficient data for specific countries. Given that the focus of this analysis is long-run growth, this may represent a weakness in the dataset, as differing growth interval lengths may result in differing measured impacts for wealth concentration (should one exist at some particular time scale). A related issue is that the start years cover a period of over 30 years, which given the variations in global economic climate during the period could result in noise that would obscure an effect if one exists. Both of these concerns will be explored in the final dissertation. It should be possible to control for both factors without excessively pruning the dataset: with a handful of exceptions the growth intervals measure at least 20 years, and with the addition of recently acquired data from the 1970 round of the World Census of Agriculture, it should be possible to restrict start years to limited ranges and still retain a majority of countries in each era.

Examining the correlation matrix for a different perspective on the data:

rgdpltot	0.3468						
workers	0.9334	0.4448					
agcap	0.2748	0.8317	0.3370				
totschl	0.4545	0.1422	0.4472	0.2155			
hsgrads	0.6765	0.3347	0.6351	0.3455	0.6529		
interval	0.4125	0.3479	0.4467	0.2383	0.0375	0.1380	
intgini	0.4700	0.0708	0.5185	-0.0590	0.1393	0.1889	0.7629
	pop	**rgdpltot**	**workers**	**agcap**	**totschl**	**hsgrads**	**interval**

Unsurprisingly, both **workers** and **hsgrads** (number of secondary school graduates) are strongly correlated with **pop** (growth in population), and thus each other. Similarly **totschl** (total years of school completed) and **hsgrads** are also strongly correlated. All things being equal, this suggests that **totschl** is preferable as a measure of human capital, it being more independent of the other exogenous variables. As part of the final research, the consequences of using the original fractional human capital data (i.e. percentage graduating from secondary school, and average years of education), in order to further reduce the correlation between the independent variables, will be examined.

Finally, some exploratory graphing exposes an outlier in the data. In the accompanying graph of GDP growth against growth in total years of schooling in the workforce, the point at the far right represents Iraq, which saw its total years of education increase by a factor of 35 over 28 years, far outstripping any other country in the sample while showing minimal economic growth. Dropping Iraq from the dataset causes the slope of the estimated relationship to more than triple (shifting from the flatter line to the steeper one). Further examination shows that Iraq exhibits a more typical relationship between GDP growth and growth in secondary school graduates, and shows a very small increase in secondary school graduates given its rise in total years of school. This, along with similar behavior for Iran and Nepal (the two points closest to Iraq above), suggests that for some countries growth in total years of school may be largely in the lowest grade levels, with relatively small effects on output. This suggests that secondary school graduates may be a better measure of human capital growth, all else being equal, which further reinforces the idea that returning to the fractional data for the final analysis would be worthwhile, as that should largely eliminate the correlation with labor supply growth which argues against relying upon **hsgrads** in the current analysis.



V. Results

Estimated Relationships

OLS Regression Parameter Estimates

Full Model Specification: $\%Y = (r_0 + r_1 G)dt + \alpha(\%K) + \beta(\%L) + \gamma(\%H)$

Variable	**Baseline Capital, Labor, Residual**	**Baseline plus Human Capital**		**Baseline plus Gini**	**Baseline plus Human Capital and Gini**	
agcap (*K*)	0.3176336 (0.030789) P=0.000	0.322786 (0.0314034) P=0.000	0.3223101 (0.0305255) P=0.000	0.3020719 (0.035561) P=0.000	0.3049827 (0.0356344) P=0.000	0.3080303 (0.0353437) P=0.000
workers (*L*)	0.608536 (0.3280627) P=0.069	0.8082138 (0.3996521) P=0.048	0.8564794 (0.359023) P=0.021	0.7612591 (0.3717339) P=0.045	1.037032 (0.4545121) P=0.026	0.9887977 (0.3957943) P=0.015
interval (*dt*)	0.0209814 (0.0110897) P=0.064	0.0211417 (0.0111134) P=0.062	0.0190633 (0.0110099) P=0.089	0.0439159 (0.283372) P=0.127	0.0490561 (0.0287282) P=0.093	0.0399761 (0.0281115) P=0.161
hsgrads (*H*)		-0.0245112 (0.0279015) P=0.383			-0.0298097 (0.0283243) P=0.297	
totschl (alternate *H*)			-0.0517409 (0.0325223) P=0.117			-0.0503632 (0.326675) P=0.129
intgini (*G*dt*)				-0.0370019 (0.042057) P=0.383	-0.0449805 (0.042695) P=0.297	-0.0336578 (0.0416059) P=0.422
Observations	60	60	60	60	60	60
Adj. R^2	0.8776	0.8771	0.8808	0.8771	0.8773	0.8801
RSS	75.5485946	74.5216058	72.2816131	74.5185683	73.047477	71.4316695
	F-Test vs. Baseline	F = 0.772 (Failed)	F = 2.531 (Failed)	F = 0.774 (Failed)	F = 0.942 (Failed)	F = 1.585 (Failed)

Standard deviations are presented in parentheses, followed by the confidence level for the estimate

Interpretation

The first observation is that the classic model including just capital, labor and the Solow residual accounts for nearly 90% of the variation in calculated growth rates, and the addition of the other variables does little to improve the fit of the model to the data, with none of the extended models achieving significance at the 5% level on a standard F-test (though some approach the 10% level). However, there are a few diamonds to be found amidst the coal. First, as predicted in the discussion of the correlation table, it appears that **totschl** serves as a more effective measure of human capital than **hsgrads**, if we take the confidence levels on the parameter estimates and associated reductions in RSS as indicators. If, as expected, this is due to the signal being muddled by correlation with **workers** (a possibility which is enhanced by the fact that the signs on the human capital coefficients are negative, a tell-tale sign of variable definition problems in log linearizations) then using the fractional data instead of the aggregate data in the final analysis may further enhance the estimates.

Another hopeful sign is that, while not statistically significant, all estimates for **intgini** are negative, and of roughly similar size, so there may be a stable effect being measured. Taking the geometric mean of the parameter estimates, the annual growth rate of a country is predicted to rise by 0.6% if the raw Gini rises by one standard deviation. This would be roughly equivalent to the predicted effects of a 2% rise in the annual rate of capital stock growth (again using the geometric mean of the parameter estimates). This is at least suggestive that concentration of wealth may be a significant factor in determining growth rates, explaining a spread of about 2.3% in the annual growth rates of high and low concentration countries. Of course, "suggestive" is not enough, and there is clearly a need for improvements in data and methods before any concrete conclusions can be drawn.

VI. Conclusions

Summary of Results

In a nutshell, the results are suggestive of a non-trivial negative relationship between concentration of wealth and subsequent economic growth, but do not achieve statistical significance. At the same time, the simplest regression shows a surprisingly good fit of a stripped-down Solow growth model and actual growth for a relatively broad cross-section of countries, so it seems likely that the effects of wealth concentration are of less importance than accumulation of inputs. Aside from this, the estimated human capital coefficients support the notion developed earlier that different forms of the human capital data than those used here may produce more precise estimates.

Areas for Further Research

Several modifications of the analysis above are underway as part of the final dissertation research, falling into three primary categories. The first is improvement of the data used in the regressions. Many aspects of this have already been discussed, including:

- reverting the human capital data back to fractional values (percentage of high school graduates and average number of years of school completed);
- expanding the selection of countries through the addition of data from the 1970 round of the World Census of Agriculture, as well as updating to version 6.2 of the Penn World Table, which covers 30 additional countries;
- aligning as far as possible the time periods covered for each country, which should be much aided by the addition of the 1970 WCA data, and where appropriate by taking advantage of the apparent long-term stability of national Gini values to proxy for missing years.

The second category is examination of alternate specifications of the regression model, which include:

- trying non-linear specifications of the Gini coefficient term, in accordance with the intuition that small changes in distribution may have larger effects under conditions of high wealth concentration than under more egalitarian distributions;

- adding data from the Polity VI series on political conditions, which may capture other structural elements which cause the residual to differ across countries;
- investigating the possibility that the distribution of wealth and the rate of economic growth may be jointly determined by some third factor;
- adding the Gini coefficient to the exponents on capital stock and/or human capital, based on arguments laid out in section III that differences in wealth distribution may result in different levels of returns to investment.

Finally, there remains the issue of whether the distribution of agricultural land is truly a reasonable proxy for the distribution of wealth, both in general and specifically for developed countries for which agriculture is a relatively small part of their total asset base. This will be explored by comparing the Gini data on land holdings with other data on general wealth holdings gathered from individual countries (such as the United States Federal Reserve's triennial Survey of Consumer Finances) to see whether they are comparable, either in size or time trend.

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Appendix I. Data

<u>Field Definitions</u>
Year: Initial year of data run for country
Interval: Years of growth; thus, a country with **Year** = 1960 and **Interval** = 1 has data covering growth between 1960 and 1961
InOECD: Whether the country was in the OECD as of **Year**
OECD: Whether the country has joined the OECD as of 2006
POP: Population growth over the measured period
rgdpltot: Real GDP growth over the measured period
workers: Growth in number of workers over the measured period
agcap: Growth in capital stock over the measured period
totschl: Growth in total years of schooling attained by all individuals aged 25 or over during the measured period
hsgrads: Growth in total number of secondary school completers (i.e. high school graduates) over the measured period
Gini: Calculated Gini coefficient of agricultural land holdings during **Year**

Country	Year	Interval	InOECD	OECD	POP	rgdpltot	workers	agcap	totschl	hsgrads	Gini
Argentina	1960	29	0	0	0.557	0.618	0.972	1.897	1.37	3.023	0.86
Australia	1960	30	0	1	0.622	2.067	0.956	2.424	0.946	1.267	0.88
Austria	1960	30	0	1	0.091	1.936	0.083	3.432	0.438	0.197	0.71
Bangladesh	1960	30	0	0	1.146	1.595	0.744	0.645	4.2	3.851	0.52
Belgium	1960	28	0	1	0.087	1.609	0.174	1.63	0.264	1.028	0.60
Brazil	1970	20	0	0	0.54	1.658	0.73	2.321	1.413	2.583	0.84
Canada	1961	29	1	1	0.516	2.236	0.928	2.585	1.406	2.246	0.53
Colombia	1960	30	0	0	1.074	3.059	1.18	2.475	2.62	5.151	0.86
Congo, Dem. Rep. of	1970	19	0	0	0.783	-0.026	0.559	1.842	3.202	12.556	0.37
Costa Rica	1950	40	0	0	2.724	6.462	2.549	11.121	5.635	19.634	0.80
Cyprus	1977	13	0	0	0.116	1.303	0.174	0.732	0.602	0.959	0.61
Denmark	1960	30	0	1	0.121	1.238	0.369	2.285	0.445	1.201	0.46
Dominican Republic	1960	30	0	0	1.2	3.039	1.308	5.479	3.739	21.733	0.80
El Salvador	1950	40	0	0	1.625	2.27	1.506	5.559	5.22	17.152	0.83
Fiji	1965	25	0	0	0.586	1.825	0.869	1.539	2.157	4.07	0.65
Finland	1960	30	0	1	0.125	2.056	0.265	2.365	1.473	11.038	0.35

Country	Year	Interval	InOECD	OECD	POP	rgdpltot	workers	agcap	totschl	hsgrads	Gini
France	1971	19	1	1	0.104	0.738	0.186	0.966	0.557	1.892	0.53
Germany, West	1960	30	0	1	0.14	1.488	0.151	2.074	0.373	0.657	0.68
Greece	1971	19	1	1	0.15	0.548	0.13	1.213	0.838	2.979	0.49
Guatemala	1950	40	0	0	1.961	3.948	1.7	3.938	5.549	15.256	0.86
Honduras	1976	14	0	0	0.564	0.65	0.675	0.686	1.735	2.593	0.76
India	1971	19	0	0	0.516	1.362	0.476	1.452	1.968	4.233	0.62
Indonesia	1963	27	0	0	0.78	4.51	0.782	12.27	4.013	21.158	0.54
Iran	1960	30	0	0	1.523	2.719	1.78	7.361	14.467	25.681	0.70
Iraq	1959	28	0	0	1.458	1.674	1.469	7.844	35.13	25.512	0.88
Israel	1971	19	0	0	0.518	1.176	0.611	1.308	0.935	1.303	0.77
Italy	1961	29	1	1	0.122	1.948	0.127	2.192	0.695	2.457	0.73
Jamaica	1961	29	0	0	0.454	1.157	0.746	0.679	1.823	7.19	0.77
Japan	1960	30	0	1	0.32	5.294	0.406	12.39	1.297	1.949	0.49
Korea, Rep. of	1962	28	0	1	0.605	8.952	1.019	26.902	4.602	10.319	0.39
Lesotho	1961	29	0	0	0.937	2.658	0.722	19.003	1.557	9.489	0.42
Malawi	1969	21	0	0	0.937	1.404	0.718	2.333	2.377	22.026	0.36
Malaysia	1960	30	0	0	1.236	5.812	1.565	12.661	4.923	9.713	0.70
Mexico	1960	30	0	1	1.305	3.263	1.457	4.919	4.99	15.877	0.73
Nepal	1972	14	0	0	0.426	0.741	0.36	2.548	15.523	13.088	0.56
Netherlands	1960	30	0	1	0.301	1.736	0.528	2.238	1.555	9.949	0.58
New Zealand	1960	30	0	1	0.417	0.984	0.711	1.567	0.872	2.182	0.73
Nicaragua	1962	28	0	0	1.328	0.596	1.197	2.634	2.829	4.734	0.80
Norway	1960	30	0	1	0.184	1.936	0.537	2.09	1.263	4.09	0.68
Pakistan	1960	30	0	0	1.354	5.438	1.333	5.373	7.268	19.282	0.66
Panama	1961	29	0	0	1.068	3.103	1.222	4.519	3.032	9.606	0.74
Paraguay	1981	9	0	0	0.314	0.391	0.324	0.765	0.779	1.348	0.93
Peru	1961	29	0	0	1.111	1.299	1.115	1.885	3.481	7.408	0.94
Philippines	1959	31	0	0	1.279	2.492	1.106	5.454	3.747	6.977	0.52
Portugal	1968	22	1	1	0.126	1.442	0.244	1.919	1.281	3.518	0.81
Senegal	1961	29	0	0	1.241	0.881	1.041	1	1.657	4.144	0.49
South Africa	1960	30	0	0	1.023	2.204	1.05	2.718	1.787	3.144	0.70

Country	Year	Interval	InOECD	OECD	POP	rgdpltot	workers	agcap	totschl	hsgrads	Gini
Spain	1962	28	1	1	0.246	2.122	0.212	3.88	1.315	4.47	0.84
Sri Lanka	1962	28	0	0	0.636	1.972	0.675	5.165	2.017	2.823	0.70
Sweden	1961	29	1	1	0.139	1.222	0.344	1.494	0.524	1.102	0.50
Syria	1961	29	0	0	1.571	4.472	1.305	5.729	8.414	23.232	0.63
Taiwan	1960	30	0	0	0.813	12.58	1.218	22.361	4.97	9.051	0.46
Thailand	1963	27	0	0	0.928	6.4	1.074	8.765	2.967	9.766	0.46
Tunisia	1962	28	0	0	0.874	3.86	1.196	2.905	8.729	10.86	0.65
Turkey	1963	27	1	1	0.879	2.596	0.668	4.691	2.997	4.8	0.64
United Kingdom	1951	39	0	1	0.138	1.65	0.208	2.958	0.389	8.016	0.71
United States	1950	40	0	1	0.638	3.09	0.886	2.669	1.697	3.377	0.70
Uruguay	1961	29	0	0	0.208	0.506	0.159	0.706	0.685	1.507	0.83
Venezuela	1961	29	0	0	1.469	1.151	1.872	1.534	4.672	11.914	0.93
Yugoslavia	1960	30	0	0	0.293	2.037	0.294	3.833	1.242	5.56	0.53

Appendix II. Annualized Data

The following data has been converted from the interval values in Appendix I to annual growth rate values as an aid to interpretation.

Country	Year	Interval	InOECD	OECD	POP	rgdpltot	workers	agcap	totschl	hsgrads	Gini
Argentina	1960	29	0	0	1.53%	1.67%	2.36%	3.73%	3.02%	4.91%	0.86
Australia	1960	30	0	1	1.62%	3.80%	2.26%	4.18%	2.24%	2.76%	0.88
Austria	1960	30	0	1	0.29%	3.65%	0.26%	5.08%	1.21%	0.60%	0.71
Bangladesh	1960	30	0	0	2.57%	3.23%	1.87%	1.67%	5.64%	5.40%	0.52
Belgium	1960	28	0	1	0.30%	3.48%	0.57%	3.51%	0.84%	2.55%	0.60
Brazil	1970	20	0	0	2.18%	5.01%	2.78%	6.18%	4.50%	6.59%	0.84
Canada	1961	29	1	1	1.44%	4.13%	2.29%	4.50%	3.07%	4.14%	0.53
Colombia	1960	30	0	0	2.46%	4.78%	2.63%	4.23%	4.38%	6.24%	0.86
Congo, Dem. Rep.	1970	19	0	0	3.09%	-0.14%	2.36%	5.65%	7.84%	14.70%	0.37
Costa Rica	1950	40	0	0	3.34%	5.15%	3.21%	6.43%	4.84%	7.86%	0.80
Cyprus	1977	13	0	0	0.84%	6.62%	1.24%	4.31%	3.69%	5.30%	0.61
Denmark	1960	30	0	1	0.38%	2.72%	1.05%	4.04%	1.23%	2.66%	0.46
Dominican Republic	1960	30	0	0	2.66%	4.76%	2.82%	6.42%	5.32%	10.97%	0.80
El Salvador	1950	40	0	0	2.44%	3.00%	2.32%	4.81%	4.67%	7.51%	0.83
Fiji	1965	25	0	0	1.86%	4.24%	2.53%	3.79%	4.70%	6.70%	0.65
Finland	1960	30	0	1	0.39%	3.79%	0.78%	4.12%	3.06%	8.64%	0.35
France	1971	19	1	1	0.52%	2.95%	0.90%	3.62%	2.35%	5.74%	0.53
Germany, West	1960	30	0	1	0.43%	3.08%	0.47%	3.81%	1.06%	1.69%	0.68
Greece	1971	19	1	1	0.74%	2.32%	0.64%	4.27%	3.25%	7.53%	0.49
Guatemala	1950	40	0	0	2.75%	4.07%	2.51%	4.07%	4.81%	7.22%	0.86
Honduras	1976	14	0	0	3.25%	3.64%	3.75%	3.80%	7.45%	9.56%	0.76
India	1971	19	0	0	2.21%	4.62%	2.07%	4.83%	5.89%	9.10%	0.62
Indonesia	1963	27	0	0	2.16%	6.52%	2.16%	10.04%	6.15%	12.15%	0.54
Iran	1960	30	0	0	3.13%	4.47%	3.46%	7.33%	9.55%	11.56%	0.70
Iraq	1959	28	0	0	3.26%	3.57%	3.28%	8.09%	13.66%	12.41%	0.88
Israel	1971	19	0	0	2.22%	4.17%	2.54%	4.50%	3.53%	4.48%	0.77
Italy	1961	29	1	1	0.39%	3.79%	0.41%	4.08%	1.83%	4.37%	0.73

Country	Year	Interval	InOECD	OECD	POP	rgdpltot	workers	agcap	totschl	hsgrads	Gini
Jamaica	1961	29	0	0	1.30%	2.68%	1.94%	1.80%	3.64%	7.52%	0.77
Japan	1960	30	0	1	0.93%	6.32%	1.14%	9.03%	2.81%	3.67%	0.49
Korea, Rep. of	1962	28	0	1	1.70%	8.55%	2.54%	12.62%	6.34%	9.05%	0.39
Lesotho	1961	29	0	0	2.30%	4.57%	1.89%	10.88%	3.29%	8.44%	0.42
Malawi	1969	21	0	0	3.19%	4.26%	2.61%	5.90%	5.96%	16.10%	0.36
Malaysia	1960	30	0	0	2.71%	6.60%	3.19%	9.10%	6.10%	8.22%	0.70
Mexico	1960	30	0	1	2.82%	4.95%	3.04%	6.10%	6.14%	9.87%	0.73
Nepal	1972	14	0	0	2.56%	4.04%	2.22%	9.46%	22.18%	20.79%	0.56
Netherlands	1960	30	0	1	0.88%	3.41%	1.42%	3.99%	3.17%	8.30%	0.58
New Zealand	1960	30	0	1	1.17%	2.31%	1.80%	3.19%	2.11%	3.93%	0.73
Nicaragua	1962	28	0	0	3.06%	1.68%	2.85%	4.71%	4.91%	6.43%	0.80
Norway	1960	30	0	1	0.56%	3.65%	1.44%	3.83%	2.76%	5.57%	0.68
Pakistan	1960	30	0	0	2.89%	6.40%	2.86%	6.36%	7.29%	10.55%	0.66
Panama	1961	29	0	0	2.53%	4.98%	2.79%	6.06%	4.92%	8.48%	0.74
Paraguay	1981	9	0	0	3.08%	3.73%	3.17%	6.52%	6.61%	9.95%	0.93
Peru	1961	29	0	0	2.60%	2.91%	2.61%	3.72%	5.30%	7.61%	0.94
Philippines	1959	31	0	0	2.69%	4.11%	2.43%	6.20%	5.15%	6.92%	0.52
Portugal	1968	22	1	1	0.54%	4.14%	0.99%	4.99%	3.81%	7.09%	0.81
Senegal	1961	29	0	0	2.82%	2.20%	2.49%	2.41%	3.42%	5.81%	0.49
South Africa	1960	30	0	0	2.37%	3.95%	2.42%	4.47%	3.47%	4.85%	0.70
Spain	1962	28	1	1	0.79%	4.15%	0.69%	5.82%	3.04%	6.25%	0.84
Sri Lanka	1962	28	0	0	1.77%	3.96%	1.86%	6.71%	4.02%	4.90%	0.70
Sweden	1961	29	1	1	0.45%	2.79%	1.02%	3.20%	1.46%	2.59%	0.50
Syria	1961	29	0	0	3.30%	6.03%	2.92%	6.79%	8.03%	11.61%	0.63
Taiwan	1960	30	0	0	2.00%	9.08%	2.69%	11.07%	6.13%	7.99%	0.46
Thailand	1963	27	0	0	2.46%	7.69%	2.74%	8.80%	5.23%	9.20%	0.46
Tunisia	1962	28	0	0	2.26%	5.80%	2.85%	4.98%	8.46%	9.23%	0.65
Turkey	1963	27	1	1	2.36%	4.85%	1.91%	6.65%	5.26%	6.72%	0.64
United Kingdom	1951	39	0	1	0.33%	2.53%	0.48%	3.59%	0.84%	5.80%	0.71
United States	1950	40	0	1	1.24%	3.58%	1.59%	3.30%	2.51%	3.76%	0.70
Uruguay	1961	29	0	0	0.65%	1.42%	0.51%	1.85%	1.81%	3.22%	0.83

Country	Year	Interval	InOECD	OECD	POP	rgdpltot	workers	agcap	totschl	hsgrads	Gini
Venezuela	1961	29	0	0	3.16%	2.67%	3.70%	3.25%	6.16%	9.22%	0.93
Yugoslavia	1960	30	0	0	0.86%	3.77%	0.86%	5.39%	2.72%	6.47%	0.53