The Empirics of Economic Growth and Industrialization Using Growth Identity Equation

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Acknowledgements: The authors are grateful to Philip R. P. Coelho and participants in the Asia-Pacific Economic Association and the Southern Economic Association conferences for their comments, David Zhang for his fund donation through the City University of Hong Kong, and Siyang Ye, Angela Yin Yao, and Pennie Pui Yan Wong for their research support. The authors are responsible for all remaining errors.

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Abstract

This study examines the determinants of economic growth and industrialization based on the Growth Identity Equation. This identity links total output growth with the performance of the three economic sectors (agriculture, industry and services) measured by their sectorial rates of output growth and weighted by each sector's output share in GDP. Using the data from 164 countries from 1970 to 2010 our study examines and explains economic growth and industrialization with economic, institutional, and other variables. We identify the causal variables for industrialization that are reflected in the structural shifts of the output ratios in the three sectors.

Keywords: Economic growth, industrialization, economic development, world economy, economic sectors, Growth Identity Equation.

Classifications: C22, O11, O50.

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I Introduction

The number of studies on the empirics of economic growth has increased substantially in the last two decades. The theories underlying the recent empirical work are, among others, the neoclassical and endogenous growth models (Ramsey, 1928; Solow, 1956, 1957; Swan, 1956; Cass, 1965; Koopmans, 1965; Romer, 1986, 1990; Lucas, 1988, 1990; and Rebelo, 1991). Both the theoretical and empirical studies on economic growth focused primarily on the growth of total output per capita usually measured by real GDP or income per capita or per worker. The growth of total output per capita is arguably the single most important variable in growth literature. To explain it both theoretic and empirical studies have used a variety of variables. The Solow or Solow-type studies use as few as four explanatory variables of physical capital, human capital, population growth, and initial GDP (Mankiw *et al.*, 1992). Other studies employed many more independent variables, such as the 20 or so independent variables employed by Barro (1991) and the 62 variables employed by Sala-i-Martin (1997).

However, the growth of an economy is not only reflected by growth in total output because there can be structural changes in social, institutional, and cultural conditions (Kuznets, 1959, 1971). Patterns of structural change across countries have been the focus of many theoretical and empirical studies. Since there are multiple facets involved in patterns of structural changes, and most facets are not directly observable, proxies for structural changes are used as dependent variables in numerous studies; for example, following Kuznets' work, Chenery and Syrquin (1975) examined the patterns of structural changes with 27 dependent variables which are grouped into 10 processes.

A major characteristic of structural change is industrialization (Kuznets, 1959, 1971). When an economy is divided into agriculture, industry and service sectors, the importance of each sector is represented by their shares in total output (GDP) and/or in employment. Structural change in an economy can be represented by how these sectors change during different developmental stages. Given that the output shares of these three sectors sum to unity, the process of industrialization can be defined as the increase in the shares of the industrial and/or service sectors along with the concomitant decrease in agriculture. A consistent observation across growing economies is that the share of agriculture declines while the shares of the industrial and service sectors increase (Clark, 1940; Fisher, 1939; Kuznets, 1971).

This paper attempts to provide an empirical explanation on the relationship between economic growth and industrialization. To establish their linkage, we use seven variables as measures of economic growth and industrialization. These variables are: the growth of real GDP per worker, the output shares of agriculture, industry, and services in GDP, and the growth of output in each of the three sectors. The choice of the growth of real GDP per worker is dictated by its wide use in the growth literature, while the other six variables are also widely used in studies on structural change and industrialization. The six variables from the three sector shares and growth rates are important because they are linked to both industrialization and growth in total output. The linkage is established through the *Growth Identity Equation* (GIE) in that the growth of real GDP per worker is on the left-hand side of the identity while the six variables for sector shares and growth are on the right-hand side. The GIE shows the relationship between the total output growth and the performance of the three sectors measured by their sector growth output, as well as by their output shares in GDP.

The hypothesis underlying the GIE in this paper is that all seven variables in the identity can be regarded as dependent variables. To explain these seven dependent variables in a reduced form we select a set of independent variables. For each of the seven dependent variables in the GIE we follow procedures common in the growth literature to select exogenous variables and identify those variables that may explain economic growth and industrialization. Using a group of independent variables to explain a group of dependent variables is similar to the methodology employed by Chenery and Syrquin (1975) and Durlauf *et al*. (2008). In explaining each of the 27 dependent variables that are measure/proxies of structural changes, Chenery and Syrquin (1975) used three independent variables: total output per capita, population, and net resource inflow (imports minus exports) as a share of total output. Similarly Durlauf *et al*. (2008) used the independent variables to explain total output growth as well as physical human capital and total factor productivity that are a part of the production function. In our study we use regression models with a set of 43 independent variables to determine the variables that can explain each of the seven dependent variables in the GIE. This is done for a sample of 164 countries from 1970 to 2010.

Section II discusses the basic literatures on economic growth, economic development and industrialization. Section III embodies the regression methodology based on the GIE framework and discussion on data categories and sources. Section IV reports our empirical findings. Section V concludes the paper.

II Literature Review

Since the Industrial Revolution of the late eighteen century, rapid economic growth has accompanied by the process of industrialization. Goodfriend and McDormott (1995) used

Maddison's (1982) data to show that total production and output per capita have dramatically increased since 1820. Economists have dichotomized the study of the growth process into economic growth and economic development. While economic growth primarily focuses on the growth of total output, economic development encompasses a more general and broader view of the growth process in developing economies.

The genesis of recent economic growth studies began in the 1950s and 1960s with neoclassical growth models (Solow, 1956, 1957; Swan, 1956; Cass, 1965; Koopmans, 1965). In the Solow model (1956), an output production function with labor and capital as inputs is used to derive the steady-state output per capita which is exogenously determined by the saving rate and population growth. Solow (1957) stressed the importance of technological changes as a source of economic growth in the production function. Although there was a flurry of further studies subsequent to these two Solow articles, the publication on economic growth subsided and continued at a relatively modest rate until the emergence of endogenous growth models in the late 1980s (Romer, 1986, 1990; Lucas, 1988, 1990; Rebelo, 1991). In endogenous growth models, the rate of total output growth is no longer exogenously determined, but is endogenously determined by human capital and technological changes.

Since then, numerous theoretical and empirical studies have debated on whether growth was endogenously determined. These debates are reflected in such issues as whether physical capital produced increasing or decreasing returns, and in the convergence theory, whether growth in poor countries has caught up with rich countries (Barro, 1991, Mankiw *et al*., 1992). The debates lead to the search for significant variables in the growth process. Variables commonly used in recent empirical works include economic, institutional, and non-institutional variables such as religion, culture, geography, and social fractionalization (Barro, 1991; Durlauf *et al*.,

2012; Easterly and Levine, 1997; La Porta *et al*., 2008; Sachs, 2003; Li and Zhou, 2010). The survey conducted in Durlauf *et al*. (2005) found more than 140 independent variables can be used in explaining total output growth.

Due to the multitude of possible independent variables, variable selection and sensitivity analysis issues arise (Levine and Renelt, 1992; Sala-i-Martin, 1997). One solution to the selection problem involves using new modeling approaches such as model-averaging methods and non-linear and non-parametric models (Sala-i-Martin *et al*., 2004; Henderson *et al*., 2011). In sum, modern empirical growth studies have used a variety of: 1) economic theories, 2) proxy variables for economic, institutional, and non-institutional effects, and 3) econometric modeling with different functional forms, estimation techniques and data sets. The common feature in these studies is that the dependent variable is the growth of total output measured by the growth of real GDP per worker or per capita. A more complete survey on the recent growth literature can be found in Durlauf *et al*. (2005).

The literature on economic development followed a separate, but similar line of the research to that of economic growth. Economic development focuses on broader issues of growth such as industrialization and structural changes. The studies on the early stage of industrialization concentrate on the shift from agricultural to industry (Deane, 1957). The concept of the tertiary (service) sector in economic development was initially studied by Clark (1940) and Fisher (1933, 1939). Based on his analysis and estimates of national income and components of national income, Kuznets (1971) focused on shares of AIS (agriculture, industry, and services) sectors in production and labor force. Kuznets (1973) also advocated a broader view of economic growth to include structural changes. With the decline of colonialism and the emergence of new nations in post-World War II, and with the concomitant additional statistical

data since 1950s, Chenery and Syrquin (1975) and Chenery *et al*. (1986) extended Kuznets's work on structural changes. The Chenery and Syrquin (1975) book focused on patterns of structural changes in 101 countries from 1950 to 1970, while Chenery *et al*. (1986) studied the role and the determinants of industrialization in economic development. Using a new data set, Jorgenson and Timmer (2011) found evidence on patterns of structural changes in advanced economies and concluded that the traditional classification of three sectors is insufficient to explain structural changes because the service sector dominates in advanced economies. The theories underlying sectorial shifts during the early industrialization period were Engle's Law and the surplus labor theory in Lewis (1954). The Engle's Law states that the proportion of income spent on food declines as income rises (Houthakker, 1957), while Lewis (1954) provided a theoretical study on the links between economic growth and the structural changes between the agricultural and industrial sectors.

Early studies on economic growth and/or economic development focused on the developed economies because both economic growth (output growth) and structural changes (industrialization) could only be observed in relatively developed economies prior to World War II. The divergence between the fields began when studies in economic development started to focus on the different aspects of the development process in newly emergent and developing countries, while these aspects have less implication in developed economies. Hence, a major difference between economic growth and economic development is that economic development focuses on aspects of the development process that primarily confront developing economies. These aspects include (among others) economic factors, such social and political factors as health, education, and income equality, and the role of institutions (Perkins *et al*., 2013, Roland, 2014, Todaro and Smith, 2015). Interestingly, a comparison of recent studies shows that many

empirical studies in economic growth apply cross-country data, including both developed and developing countries. Additionally, the independent variables used in explaining total output growth include both institutional and non-institutional variables (Durlauf *et al*., 2005). The empirical studies in the two fields appear to be converging, and the convergence appears to be concentrated mainly in the usage of independent variables and data (countries included in the estimation). Dependent variables seem to be immune to this trend and are still fundamentally different between the two fields: one focuses on total output growth and the other focus on broader issues of structural changes and industrialization.

We use the Web of Science to compare and assess the volume of research in economic growth and economic development separately. In the database we did a keyword search of the publications to include only the terms: "article", "book review", "proceeding paper", "review", and "book chapter". Using "economic growth" as the keyword the total number of publications from 1956 to 2014 is 13,642; with "economic development" as the keyword, the total is 8,182. Figure 1 depicts the keyword search results for the number of publications per year from 1956 to 2014. The two series are relatively close prior to 1990; subsequently the number of publications in economic growth rose rapidly. Sorting search results by "times cited," (which is the number of times the publication was cited) the top three articles in "economic growth" for the sample period are: Solow (1956) with 3,204 times cited, Barro (1991) with 2,280, and Mankiw *et al*. (1992) with 1,989. This suggests that the rapid increase in studies of economic growth since 1990 is mainly due to the endogenous growth literature. For the top three articles in "economic development", Lucas (1988) has 3,801 times cited, while the second and third most cited articles have less than one-third of Lucas's with 997 and 720, respectively. It is interesting to note that Lucas's article is a major work in economic growth, yet it is classified as in "economic

development" in the Web of Science probably because of the title of his article. He included "economic development" in the title since his model targeted a growth theory applicable to both developed and developing economies. Strictly speaking, the article should be classified as an economic growth article since the dependent variable is still the level and the growth of per capita income.

The widening gap between the two series depicted in Figure 1 may lead one to believe that convergence of the two fields is not happening. The two fields are closely related in studying the early stages of industrialization because of the coexistence of economic growth and industrialization, and they also show some convergence as evidenced by recent studies in economic growth that have included institutional and non-institutional independent variables and used data of all countries. Coexistence and convergence inspire us to examine the relationship between economic growth and industrialization, though the issue of causality arises. The correlation between income per capita and sectorial shift in Kuznets (1971) formed the base of the regression model in Chenery and Syrquin (1975) that used income per capita as an independent variable to explain the sector shares primarily based on Engle's law. Chenery *et al*. (1986) determined the sources of industrialization and the relationship between economic growth and industrialization after recognizing that their relationship is subject to continuing controversy. Laitner (2000) provided a theory that incorporated the saving rate as an endogenous variable that induced output growth in the process of economic development, implicitly recognizing that structural changes (industrialization) caused output growth through their impact on the rate of saving. Dietrich (2012) empirically examined the causal relationship with panel data for seven OECD countries. Without considering causal relationship, Li (2014) used a group of variables to generate economic opportunity indices as alternative measures of economic growth and progress.

A major purpose of this paper is to study the determinants and relationships of total output growth and industrialization in one framework. The integration of the two fields requires building a model with dependent and independent variables. The following section demonstrates our reasoning in identifying variables and methodology.

III Methodology and Data

We use a mathematical identity to link economic growth and industrialization. Suppose economic growth is measured by total output growth, while industrialization is represented by sectorial shifts in economies. To relate total output growth and sectorial shift we begin with the three-sector classification of the total real output per capita:

$$y_t = a_t + i_t + s_t, \quad (1)$$

where y_t is real per capita GDP; a_t , i_t and s_t represent real output per capita in agriculture, industry and service sectors, respectively, expressed at time t. Dividing each term in Equation (1) by total output, y_t, yields the following:

$$(a/y)_t + (i/y)_t + (s/y)_t \equiv 1, \quad (2)$$

where $(a/y)_t = \frac{a_t}{y_t}$, $(i/y)_t = \frac{i_t}{y_t}$ and $(s/y)_t = \frac{s_t}{y_t}$ indicate the share of agricultural output, industrial output and service output in GDP, respectively. The sum of the output shares of three sectors has to equal to one. Industrialization and structural shifts among sectors can be seen from the changes in the components of the identity. During industrialization, we observe declines in

the agriculture sector's share in GDP and corresponding increases in the industrial and service sectors' share in GDP.

In addition to sectorial shares we are concerned with the growth of output in each of the sectors. Denote the growth of output as:

$$\dot{y}_t = \frac{y_t - y_{t-1}}{y_{t-1}}, \dot{a}_t = \frac{a_t - a_{t-1}}{a_{t-1}}, \dot{i}_t = \frac{i_t - i_{t-1}}{i_{t-1}}, \dot{s}_t = \frac{s_t - s_{t-1}}{s_{t-1}}, \quad (3)$$

where $\dot{y}_t$ is the growth of real GDP per capita (this is the measure of economic growth); $\dot{a}_t$, $\dot{i}_t$ and $\dot{s}_t$ indicate, respectively, the growth of real output per capita in the agriculture, industry and service sector. Using y_t and y_{t-1} in Equation (1) to calculate the total output growth ($\dot{y}_t$) and using Equation (3), we derive the following Growth Identity Equation (GIE):

$$\dot{y}_t \equiv (a/y)_{t-1}\, \dot{a}_t + (i/y)_{t-1}\, \dot{i}_t + (s/y)_{t-1}\dot{s}_t. \quad (4)$$

Total output growth in the identity is equal to the weighted sum of sectorial growth, where the weight for each sector's growth is its output share in GDP in the previous period. Since Equation (4) is true for all t, the identity shows that long-term total output growth rate $\dot{y}$ is related to the long-term industrial structure (the three sector shares, $\left(\frac{a}{y}, \frac{i}{y}, \frac{s}{y}\right)$) and each sector's long-term growth rate $(\dot{a}, i, \dot{s})$.

To determine the causal relationship among the seven variables in the GIE, we consider the nature and the properties of the equations. There are several types of equations used in economics: 1) functional forms such as production function, where output *Y* is a function of labor L and capital K, $Y = f(L, K)$, and the demand function, where quantity demanded Q_D is a

function of price P, $Q_D = f(P)$; 2) economic equations such as the equilibrium condition for supply S and demand D, $S = D$; 3) accounting identities such as Equation (1) and the GDP identity from the expenditure side: $Y = C + I + G + X - M$, which shows that total output Y is the sum of consumption C, investment I, government expenditure G, and net exports (exports X minus imports M); and 4) mathematical identities such as Equations (2) and (4). The equations with mathematical definitions such as Equation (3) can also be classified as mathematical identities.

The variable on the left-hand side of a functional form in 1) must be a dependent variable, and the variables in an economic equation must have a causal relationship based on economic theories. The accounting identity may or may not have a causal relationship. The accounting identity in Equation (1) is a simple decomposition of the total output into three sectors and there is no causal relationship. The GDP expenditure identity becomes an economic equation once we assume consumption is a function of income. A mathematical identity is simply derived from mathematics without a causal relationship. Because Equation (4) is a mathematical identity, we can consider the variables on the left-hand side and on the right-hand side as simultaneously determined. We treat all seven variables in the identity as dependent variables endogenously determined by a system of equations.

To estimate the seven dependent variables, consider the reduced form:

$$z = f(X), \tag{5}$$

where z is one of the seven variables in the set $\left\{\dot{y}, \frac{a}{y}, \frac{i}{y}, \frac{s}{y}, \dot{a}, i, \dot{s}\right\}$ and X is a vector of variables with all possible exogenous variables. Each independent variable may not have the same impact

on each of the seven dependent variables. For example, the variables that affect total output growth may or may not have the same effects on the six variables on the right-hand side of the GIE; the variables that affect sectorial shift may not have the same effects on sector growth, and so on. Suppose x is one of the independent variable, and based on Equation (2), we derive the following constraint:

$$\frac{\partial(a/y)}{\partial x} + \frac{\partial(i/y)}{\partial x} + \frac{\partial(s/y)}{\partial x} \equiv 0. \quad (6)$$

This indicates that the total impact of any independent variable on the output shares of the three sectors should be zero. The identity also provides a basis for understanding structural shifts. For example, $\frac{\partial(a/y)}{\partial x} < 0$, $\frac{\partial(i/y)}{\partial x} > 0$, and $\frac{\partial(s/y)}{\partial x} > 0$ implies the decrease in the share of the agriculture sector and the increase in the shares of industrial and service sectors are related. This indicates that industrialization is caused by the x variable. When we observe industrialization with cross-country data, we expect the coefficients of most of the independent variables to be negative in regressions where the share of the agricultural sector is the dependent variable. Conversely in regressions where either the share of the industrial sector or the share of the service sector is the dependent variable then, the coefficients of most independent variables are expected to be positive. Comparing positive and negative estimated coefficients we can find the determinants of industrialization.

Although Chenery and Syrquin (1976) consider the estimation of three sector shares among the 27 dependent variables, their analysis is different from ours. Their estimations include only three independent variables. The exclusion of all other possible exogenous variables can be improved by using additional independent variables provided by the recent literature. Most of the

27 dependent variables in their study are expressed in shares of GDP. They recognized that the partial effects of each exogenous variable must total to zero when the sum of all shares is 100 percent such as in Equation (6). However, they failed to realize the importance of Equation (6). Their analysis of structural shifts, rather than focusing on regression results, relied mainly on the illustration of two-dimensional graphs with three sector shares on the vertical axis and an independent variable on the horizontal axis. Instead we use a wide range of explanatory variables in regressions and Equation (6) to identify the determinants of industrialization. Another concern of their analysis is the causality or endogeneity; one of the three independent variables in their estimation is income per capita, a measure of economic growth. This implicitly assumes that economic growth causes industrialization and structural changes. The GIE implies that we should consider both total output growth and sector shares as endogenous variables.

The focus of Chenery *et al*. (1986) is similar to our paper: finding the sources of economic growth and industrialization using the relationships between the two. Their methodology in chapters 2 and 3 is close to ours with some differences. They divide the analysis into two separated parts: an explanation of economic growth and an explanation of industrialization (represented by the changes in economic structure or sectorial shifts). In every part of their analysis, they treated one or the other as exogenously determined. In Chapter 2, Chenery (1986) introduced a growth accounting equation (Equation (2-9), p. 32), which is the same as our GIE. He assumed sectorial shares are fixed and estimated the sector growth from the supply-side decomposition. Based on the GIE, he focused on total output growth with fixed sector shares and the estimated sector growth. The analysis assumes that the economic structure is exogenously given and fixed. In chapter 3, Chenery and Syrquin (1986) examined the five components of GDP (consumption, investment, government expenditure, exports, and imports),

sector outputs, the five components in each sector, and sector shares or changes in the economic structure. Although other exogenous variables (the capital stock per capita, skills per capita, population size, natural resources per capita, and allocation policies) are mentioned, their analysis is mainly based on income per capita as the independent variable. Both Chenery (1986) whom treated sectorial shares as fixed and used sector growth to explain total output growth and Chenery and Syrquin's (1986) whom used income per capita to explain sectorial shifts and growth pose a sharp contrast to our work. In our model, total output growth and the six variables from the three sectors are all endogenously determined dependent variables. We avoid the problem of treating one of the two (economic growth or industrialization) as an independent variable to explain the other. We use a set of exogenous variables to estimate the seven dependent variables in reduced form. Most importantly, using Equation (6) in the estimations of sector shares can decide the determinants of industrialization.

Durlauf *et al*. (2008) studied the impact of a set of variables on total output growth and three underlining components: total factor productivity (TFP) growth, physical and human capital accumulation. The total output growth and these three components are a part of the growth accounting which is derived from an aggregate Cobb-Douglas production function with physical and human capital as exogenous variables. The Durlauf *et al*. (2008) approach of using a set of exogenous variables to explain a set of dependent variables is similar to ours, but with a major difference in the use of growth identity. Their growth accounting equation is based on the production function while our GIE is based on the sector decomposition. Their approach of treating physical and human capital as exogenous in the production function and treating these variables as dependent variables in growth accounting involves contradicting assumptions as in Chenery *et al*. (1986).

We use the contemporaneous growth literature to identify exogenous variables X to explain the seven dependent variables in the GIE. The studies in growth literature have employed many independent variables to explain total output growth. We expect that some variables employed in the literature may be useful in explaining the six dependent variables on the right-hand side of the GIE. We selected the following independent variables grouped in six sub-categories (with the number of variables in each sub-category in the parenthesis) for our regressions:

1) Solow Variables (4): domestic investment to GDP ratio, secondary school enrollment ratio, population growth, and initial year GDP per worker;
2) Policy Variables (8): exports and imports to GDP ratios, foreign direct investment as percent of GDP, net inflows of portfolio equity in the balance of payment as percent of GDP, domestic credit to private sector as percent of GDP, development assistance and aid received as percent of GDP, the inflation rate, and CO2 emission;
3) Demographic Variables (3): life expectancy, fertility rate, and mortality rate;
4) Geographic Variables (5): land locked, latitude, tropical area, eight regions, and area;
5) Institutional Variables (12): legal origin, religions (3), political rights, property rights, regulation of business index, ethnic, language and religious fractionalization, transition economies, and export categories (manufactures, fuels, nonfuel primary products, services, diversified and others); and
6) Human Rights Variables (11): freedom of speech, religious freedom, independence of judiciary, electoral self-determination, freedom of assembly, freedom of domestic and

foreign movement, worker's rights, women's economic and social rights, Physical Integrity Rights index based on torture, killing, political imprison, and disappearance.

The estimations employ cross-country data with the General to Specific (G-to-S) modelling (Hoover and Perez, 2004), which is an alternative to sensitivity analysis. In this approach all independent variables are used in the regressions in the first step, but in the second step, the insignificant variable with the highest *p*-value is removed. Each of the following steps removes another insignificant variable with the highest *p*-value; this procedure is iterated until all remaining variables are significant. With each removal an *F* test for the most recent three removed variables is conducted for a redundant variables test. In all the iterations, we keep four Solow variables. The estimated coefficient of each Solow variable is presented in the regression results regardless of its insignificance.

Our estimations use data from 164 countries from 1970 to 2010. The data are collected from the World Bank, Penn World Table (PWT 8), Global Development Network Growth Database, CIRI Human Rights Dataset, and studies by La Porta (1999) and Alesina (2003) (see Appendix Table A1). We use real GDP per worker to measure total output growth. The data of real GDP per worker are from the PWT 8 while the sector shares are from the World Bank.

IV Empirical Results

Our regression methodology is based on the GIE shown in Equation (4). The left-hand side variable of the GIE is total output growth (measured by real GDP per worker); the six right-hand side variables include the sector shares and growth of agriculture, industry and services. Table 1 shows the averages of the seven variables from 1970 to 2010 for the sample of all

countries and for the four country income groups as classified by the World Bank. For the total output growth in column (3), the upper-middle income (UM) countries grew fastest among the four income groups during 1970-2010. Columns (5) – (7) show that as countries move from the low income group to the high income group, the share of agriculture sector in GDP declines and the shares of industry and service sectors in GDP increase. Table 1 also shows that the service sector has the highest share among three sectors for all countries and in the four income groups. Comparing the growth of the three sectors, columns (8) – (10) show that the agriculture sector has the slowest growth rates among the three sectors (with a negative growth rate or less than 1% growth per annum). The industry sector is growing faster than the service sector in the low income group and lower-middle income group countries; the service sector is growing faster than the industry sector in the upper-middle group and high income group countries.

Table 1 includes the descriptive statistics of the averages of the seven variables. Most importantly, it shows the properties of the GIE. The properties and the derivation of the GIE are simple, but its identity property has not been empirically presented and proved with data correctly. Columns (3) and (4) in Table 1 show the total output growth on the left-hand side of the GIE is exactly identical to the fitted total output growth based on the six variables on the right-hand side; this proves the identity. The implication is that the variable on the left-hand of the GIE and the variables on the right-hand side of the GIE are simultaneously determined. With this implication, we consider a set of exogenous variables to explain the seven dependent variables in the GIE.

We begin with the four Solow variables: the domestic investment to GDP ratio (GDI), secondary school enrollment percentage (Education), population growth (Population), and the logarithm of initial year GDP per worker. For the Education variable we use a quadratic form as

a simple nonlinear function. The regression results of these independent variables on each of the seven variables in the GIE are shown in Table 2. With total output growth as the dependent variable in column (1) the results should be consistent with the current growth empirics; both GDI and Education are expected to have positive and significant impact, while both population growth and initial GDP per worker should have negative and significant impact. Except for Education, the rest of the three Solow variables in our results are consistent with the current growth literature.

In addition to the examination on the impact of the given variables on total output growth, this paper is intended to focus on their impact on the six dependent variables on the right-hand side of the GIE, namely three variables for the sector shares and three variables for the sector growth. In columns (2) – (4) in Table 2 with the sector shares in GDP as the dependent variables, the coefficients of each independent variable in these three columns always sum to zero (as stated in Equation (6) and proved by Nicholson (1957)). For example, the absolute value of GDI coefficient for the share of agriculture output (−0.368) is equal to the sum of the positive values of the two output shares of industry and service sectors (0.312 + 0.056). This implies that we can compare the coefficients in these three columns to find the determinants of industrialization and structural shifts among sectors. We found GDI has a negative impact on the share of the agriculture sector and a positive impact on the share of the industrial sector; initial GDP per worker has a negative impact on the share of the agriculture sector and positive impact on the shares of the industry and service sectors. We can conclude that GDI has contributed to the industrialization and sectorial shifts. This provides an empirical evidence for finding a source of industrialization and sectorial shifts.

The negative coefficient for the initial GDP per worker in the total output growth regression in column (1) supports the convergence theory, which argues that the poorer countries grow faster than the richer countries. When the initial GDP per worker is used to explain the sector shares (columns (2) – (4)), it shows that the countries with a higher initial GDP per worker have higher industrialization process such that both industry and service sectors are increasing in the shares of GDP when compared to agriculture. This result has an interesting implication: lower income countries may grow faster, but their industrialization process is not as favorable as those in high income countries.

Population growth has a negative coefficient for total output growth; this is consistent with current growth empirics. Population growth also has a negative impact on the growth of services, but no impact on the other five dependent variables. The results for Education in columns (2) – (3) indicate that education has a nonlinear impact on the shares of both agricultural and industrial sectors. With an insignificant coefficient for Education and significantly positive coefficient for Education-squared (0.143) for the share of agriculture in column (2), this implies that education has a positive impact on the share of the agricultural sector with an increasing rate. The positive coefficient of Education (0.245) and the negative coefficient of Education-squared (-0.191) for the share of industry in column (3) imply that education has a positive impact on the share of industry with a decreasing rate until the secondary school enrollment ratio reaches 64%; this is derived from the first order condition (0.245 + 2 (–0.191) Education = 0). Columns (5) – (7) show that the Solow variables have relative low explanatory powers in explaining the sectorial growth. Only GDI has a positive and significant impact on the growth of industry, and population growth has a negative impact on the growth of services.

Table 3 shows the results when policy and demographic variables are added to the regressions. All Solow variables are retained in the regression results regardless of their level of significance. For the other independent variables only those that are significant (with at least a level of 10%) are retained in the final iteration of the G-to-S modelling. Column (1) in Table 3 shows that policy variables have no impact on total output growth while both life expectancy and mortality increase total output growth and, in contrast, fertility reduces total output growth. The coefficient of population growth becomes insignificant as it is correlated to demographic variables. For the sectorial shift, columns (2) – (4) show that education has an impact on structural shifts, which is different from the results reported in Table 2. Education has a positive impact on the share of industry until the secondary school enrollment ratio reaches 72%. This is derived from the first order condition (0.355 + 2 (–0.247) Education = 0) and Education has a positive impact on the share of services when the enrollment ratio exceeds 85% (this is derived from the first order condition, –0.346 + 2 (0.203) Education = 0). This implies that education contributes to industrialization by increasing the share of industry first, followed by increasing the share of services. The changes in the significances of the education coefficients from Table 2 to Table 3 suggest that policy and demographic variables are important in explaining sectorial shifts; compared to the regressions with only Solow variables the inclusion of these variables changed the regression results.

The three variables that contribute to industrialization and sectorial shifts are: exports and imports as a percentage of GDP, and domestic credit to the private sector (Credit). Exports cause the sectorial shift from agriculture and services to industry; while imports cause the sectorial shift from industry to services. Domestic credit to the private sector causes the sectorial shift from agriculture and industry to services. The four variables that impede industrialization are:

foreign direct investment (FDI), net official development assistance and official aid received as percentage of GDP (Dev. Aid), life expectancy, and mortality. FDI shifts the share from industry to agriculture; mortality shifts the share from services to agriculture; development assistance and aid increases the share of agriculture; and life expectancy reduces the share of industry. Columns (5) – (7) show that policy and demographic variables have no impact on sectorial growth with the exception of industry.

Comparing Table 3 with Table 2, the inclusion of policy and demographic variables in Table 3 almost doubled the original adjusted R-squares for the regressions for the shares of the industrial and service sectors and the growth of industry. This indicates that policy and demographic variables are as important factors as the Solow variables in explaining industrialization and sectorial shifts. However, the increases in the adjusted R-squared for total output growth, the share of agriculture, and the growth of agriculture and services are rather moderate with increases of only 0.091, 0.083, 0.025, and 0.024, respectively.

Table A2 in the appendix shows the details of the regression results with added geographic and institutional variables. The geographic and institutional variables are country fixed factors that do not vary over time. The inclusion of these fixed factor controls for country characteristics. As these geographic and institutional variables are added to the regressions, the adjusted R-squares for the shares and growth of industry and services all increase by more than 10%. The highest increase in the adjusted R-square is for the growth of services, 35.6%. This indicates that the fixed country factors have a major impact on the growth of services and also contribute some degree to sectorial shift and the growth of industry. The added variables have a relatively small impact on total output growth, and the share and growth of agriculture with increases in the adjusted R-squared of 0.096, 0.078 and 0.056, respectively.

The detailed results with all added variables are shown in Table A3 in the appendix. When added to regressions, human rights variables further increase the adjusted R-squares by: 1) more than 20% for the growth of industry and services, 2) between 10% and 20% for total output growth and the shares of industry and services, with 0.153, 0.152, and 0.111, respectively, and 3) less than 10% for the share and growth of agriculture, with 0.082 and 0.087, respectively. This concludes that the human rights variables contribute more to the sectorial growth than to the shares of industry and services.

The detailed results in Table A3 are summarized in Table 4. It shows the impacts of each variable in each sub-category on three sets of dependent variables (total output growth, sectorial shares and shifts, and sectorial growth). The letters A, I and S represent the agricultural, industrial, and service sectors, respectively. Upward and downward arrows respectively indicate regression results of positive and negative coefficients, while the sideway arrow indicates sectorial share changes or sectorial shifts.

Table 4 shows that among the four Solow variables, GDI is the most important one as it promotes total output growth, leads to sectorial shifts in favor of industry as well as growth in the industrial and service sectors. The negative coefficient of initial GDP per worker for total output growth implies that growth convergence is only for total output growth. High initial GDP per worker is related to the sectorial shift from agriculture to services and has a positive impact on the growth of industry. This implies that the industrialization process is higher for those countries with high initial incomes and sectorial shifts are moving more toward services than industry. Population growth has a negative impact on the growth of total output, industry and services, and has a positive impact on the share of services. The variable Education appears not to have any significant impact.

Four of the eight policy variables are important to all three sets of dependent variables; although there are differential sectorial effects among the independent variables. Both exports and FDI have a positive impact on the growth of total output, industry, and services; exports increase the share of industry and FDI increases the share of services. Two variables with negative impacts on growth and industrialization are imports and Portfolio. Imports reduce the growth of total output, industry and services. However, imports shift the share of industry to services. This implies that net capital inflow (exports minus imports) promotes total output growth and industrialization. These results buttress the importance of economic openness, supporting the arguments in other studies (e.g. Kuznets, 1971, Chenery *et al*., 1986, Li and Zhou, 2010). Portfolio reduces the growth of total output, industry, and services; it also shifts the share of industry in favor of agriculture. Because FDI and portfolio are highly correlated, the negative impact of the portfolio variable is somewhat offset by the positive impact of FDI. The impact of other policy variables include: the positive impact of CO2 on total output growth, the sectorial shift from agriculture to services caused by Credit, the positive impact of inflation on the share of industry, and the mixed impact of Aid. Aid shifts the sectorial shares from industry to agriculture, but it has a positive impact on the growth of industry and services. We conclude that Aid is the only policy variable with a negative impact on industrialization. The positive effect of Aid on the share of agriculture may indicate that Aid is targeting in helping agriculture.

With respect to demographic variables, the increase in life expectancy increases the growth of total output and services; life expectancy also reduces the sectorial share of industry to the benefit of services. An increase in fertility has only one effect; it increases the growth of services. One puzzling result is that higher mortality rates increase the growth of total output,

industry, and services; while a higher mortality rate reduces the share of industry, and increases that of agriculture.

The impact of geographical variables shows regional differences. The positive and negative coefficients for different regional dummy variables represent better or worse performance, respectively, for countries in different groups than countries in the base group. Compared to counties in Western Europe as the base group, the growth of total output, industry and services are higher in Eastern Europe and Central Asia; the growth of agriculture is higher in Eastern Asia and the Pacific. In contrast, total output growth is lower in the Sub-Sahara, North America, Latin America, and transition economies; the growth of industry and services are lower in the Sub-Sahara and Latin America; and the growth of industry is lower in transition economies. Compared to Western Europe sectorial shifts tend to favor the industrial sector in East Asia and the Pacific, along with declining shares in the agricultural sectors of South Asia, Sub-Sahara, and Latin America. Other effects of geographic variables include: the growth of total output and services are higher for countries in tropical areas; the further away from the equator the lower is the growth of industry and the greater is the sectorial shift from industry to agriculture; and landlocked countries have a lower growth in services and sectorial shifts from agriculture and services to industry.

The set of institutional variables show some interesting results. Compared to countries with a British legal system as the base group, countries with a German legal system have a higher growth in total output; countries with a Scandinavian legal system have a higher industrial growth; and countries with a French legal system show sectorial shifts from agriculture to industry and services. However, countries with French and Socialist legal systems have a lower growth in services, and countries with a German legal system have lower growth in both industry

and services. And countries with a socialist legal system show a higher share of agriculture than countries with a British legal system. An increase in the percentage of the Catholic population increases the growth of services and moves the sectorial shares from services to industry. However, an increase in the percentage of the Muslim population reduces the growth of industry and services and moves the sectorial shares from industry to agriculture. Less business regulation promotes the growth of services, but moves the sectorial shares from industry to agriculture. Fuel-exporting countries show lower growth in total output, industry and services, but the sectorial shifts from agriculture and services to industry. Nonfuel-exporting countries show an increase in the share of agriculture. Increases in ethnic divisions and conflicts reduce total output growth, but move the sectorial shares from agriculture to industry. On the contrary, increases in language divisions and conflicts move the sectorial shares from industry to agriculture.

The results of the 11 human rights variables can be divided into three groups: group 1, variables with a positive impact on growth and industrialization, group 2, variables with a mixed impact, and group 3, variables with a negative impact. The Group 1 variables (those with a positive impact) include religion freedoms, women's political rights, freedom of domestic movement variables, and freedom of assembly and association. Religion freedoms and women's political rights are positive forces for the growth of total output growth, industry, and services. Religion freedoms also reduce the share of agriculture, and women's political rights move the sectorial shares from agriculture and services to industry. Freedom of domestic movement has a positive impact on the share and growth of services, and it reduces the growth of agriculture. Freedom of assembly and association increases the growth of agriculture.

The Group 2 variables (those with a mixed impact) include: freedom of foreign movement, an independent judiciary, and physical integrity. Freedom of foreign movement has a

positive impact on the growth of services, but it moves sectorial shares from industry and services to agriculture. An independent judiciary moves the sectorial shares from agriculture to industry, but it reduces the growth of each of the three sectors. Physical integrity has mixed impacts on all seven variables, except on the share of industry; but it affects the share of industry positively. The Group 3 variables (those with a negative impact) include: freedom of speech, election, worker's rights, and women's economic rights. Freedom of speech and election reduce the growth of total output, industry, and services; freedom of speech moves the sectorial shares from industry to agriculture; finally the election variable reduces the share of industry. Worker's rights reduce the growth of total output and services, and it moves the sectorial shares from industry to agriculture. Women's economic rights reduce the growth of total output and each of the three sectors; it also reduces the sectorial shares of industry and services.

Table 5 summarizes the adjusted R-squared as different sets of independent variables are added to the regressions. All the adjusted R-squares for the seven regressions with all independent variables are above 0.70, with the exception of the growth of agriculture with an adjusted R-squared of 0.276. The low explanatory power in the regression with the growth of agriculture may imply that the agriculture sector is a declining sector. Although it is difficult to explain the growth of agriculture, the adjusted R-squared for the share of agriculture is the highest (0.92) among the seven regressions. This indicates that agriculture's declining share can be explained along with the increasing shares in the industrial and service sectors. In the regression for the share of agriculture, the adjusted R-squared with only Solow variables is 0.677. From Table 2, we can conclude that both GDI and initial GDP per worker explain more than one-half of the adjusted R-squared of the share of agriculture when all variables are included as independent variables.

Table 5 indicates that the whole set of the considered independent variables have substantial explanatory powers in the total output growth regressions, the industrialization regressions, and those for the growth of the industrial and service sectors. The high adjusted R-squares also demonstrate a property of the GIE: the variables that explain total output growth on the left-hand side of the GIE also explain the variables on the right-hand of the GIE.

Table 5 also shows that different sets of variables have different effects on each of the seven dependent variables. The Solow variables are mostly important in the regressions relating to total output growth and the share of agriculture. Policy and demographic variables have relatively large impacts on the growth and share of industry. The main impact of the geographical and institutional variables is on the growth of services. The human rights variables have mild impacts on all seven variables. Nevertheless, one can argue that in aggregate the added variables in conjunction with the Solow variables are important to explain growth, sectorial changes, and industrialization.

V Conclusions

The empirics of economic growth have increased rapidly in the recent past. This paper attempts to apply current growth literature to the study of the empirics of industrialization. Representing economic growth by total output growth, and representing industrialization by the sectorial shifts from agriculture to industry and services, we use the Growth Identify Equation to demonstrate the relationship between economic growth and industrialization. The left-hand side of the identity is total output growth, which is measured by the growth of real GDP per worker; the six variables on the right-hand side are sectorial shares and rates of growth of agriculture, industry, and services. The use of the GIE has three implications. Firstly, the GIE is a

mathematical identity relating total output growth to sectorial shares and the rate of growth of agriculture, industry, and services. We argue that all seven variables in the identity are simultaneously determined, and we treat these variables as dependent variables. Secondly, we consider a set of the independent variables derived from current growth literature to estimate the reduced form of the seven dependent variables. The third and final implication is that as the sum of the impact of each independent variable on the three sector shares should be equal to zero, we can determine the factors that affect structural shifts in the three sectors and industrialization through the regressions with the shares of the three sectors as dependent variables.

We develop regression models for total output growth, sectorial shares, and the growth in the agricultural, industrial and service sectors, using those independent variables that are employed in the current literature on growth empirics. With the data from 164 countries for the period from 1970 to 2010 we have a total of 43 independent variables explaining seven dependent variables identified by the Growth Identity Equation. The independent variables include four main categories: four Solow variables, 11 economic policy and demographic variables, 17 institutional and geographical variables, and 11 human rights variables. To address the sensitivity analysis issue in selecting independent variables, we adopted the General to Specific Modelling.

There are several key findings. First, we verify the GIE with the empirical data. Second, we show that the potential variables used to explain total output growth can also explain sector shares and growth with similarly high regression explanatory powers (with the aforementioned exception of the growth of agriculture). Third, we found different categories of independent variables have a different impact on each of the seven dependent variables. Solow variables have greater effects on total output growth and the share of agriculture than on five other dependent

variables. When added to Solow variables, policy and demographic variables significantly contribute to explain sectorial shares. The effects on the sectorial growth are less straightforward. The lowest adjusted R-squared for agricultural growth implies that the agriculture sector is a declining sector, and is somewhat isolated from the economy in aggregate. Both the Solow variables and the policy and demographic variables have similarly large relative effects on the growth of the industrial sector. Geographic and institutions variables have more significant effects than the independent variables in other three categories on the growth of the service sector. In general, as more variables from additional categories are included in the regressions, the adjusted R-squares improved.

Fourth, some independent variables have clear and consistent effects, while other variables have scattered effects on growth and sectorial shifts. We identify variables that affect growth and industrialization. The empirical results on total output growth are in line with the current growth empirics. We found that GDI and net exports are important to total output growth and the results support the convergence theory. Population growth is negatively related to the growth of total output, industry, and services; but it contributes to the increase in the share of services. Education may have nonlinear impacts on sectorial shifts and industrialization. But, it is not a robust variable in explaining any of the seven dependent variables. The addition of other categories of variables results in certain impacts on total output growth. Several Solow variables and policy variables are identified that have a positive impact on industrialization. Particularly, GDI and net exports are important in sectorial shifts in industrialization. The degree of industrialization is also positively related to the initial level of GDP. Other categories have similar effects on both total output growth and industrialization. The list of Solow and policy variables that have positive impacts on the growth of industry and services include: GDI, net

exports, FDI, and Aid. The only variable that has a positive impact on the growth of agriculture is freedom of assembly and association.

The contribution of this paper is that we use the Growth Identity Equation to establish a theoretical linkage between economic growth and industrialization. Our empirical results support this link, and also provide some insights on the variables that impact growth and industrialization.

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Table 1: Growth Identity Equation

Averages of Annual Growth and Shares, 1970 – 2010

	N	Number of Countries	Total Output Growth	Fitted Output Growth*	A/GDP	I/GDP	S/GDP	Agri. Growth	Industry Growth	Services Growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
All	4,936	164	1.61	1.61	17.36	30.39	52.25	-0.28	2.18	2.94
LI	829	26	0.57	0.57	39.86	18.39	41.75	0.66	2.59	2.15
LM	1,156	40	1.46	1.46	24.08	29.70	46.21	0.36	2.49	2.41
UM	1,259	45	2.10	2.10	12.76	33.78	53.46	0.15	2.54	3.41
HI	1,692	53	1.86	1.86	5.16	34.22	60.62	-1.50	1.52	3.33

* The fitted output growth is the average for the sum of the right-hand side of Equation (4).

Notes: The numbers, except N and number of countries, are expressed in percentages. The income group classification based on the World Bank divides countries into four groups. LI is for low income group; LM is for lower−middle income group; UM is for upper−middle income group; and HI is for high income group.

Table 2 Regressions with Solow Variables, 1970-2010

	Output Growth	A/GDP	I/GDP	S/GDP	Agriculture Growth	Industry Growth	Service Growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDI	0.173***	−0.368*	0.312**	0.056	0.036	0.345*	0.344
	(0.05)	(0.16)	(0.12)	(0.16)	(0.04)	(0.16)	(0.23)
Initial GDP	−0.764***	−7.686***	2.877*	4.817**	−0.251	−0.746	−0.298
	(0.18)	(1.12)	(1.36)	(1.71)	(0.36)	(0.46)	(0.50)
Population	−0.282*	0.822	0.493	−1.320	0.079	0.151	−0.532*
	(0.14)	(0.76)	(1.10)	(0.93)	(0.30)	(0.31)	(0.26)
Education	0.029	−0.221	0.245*	−0.025	−0.039	−0.041	−0.061
	(0.02)	(0.12)	(0.12)	(0.13)	(0.04)	(0.06)	(0.09)
Education^2	−0.012	0.143*	−0.191*	0.048	0.009	0.018	0.025
	(0.01)	(0.07)	(0.08)	(0.08)	(0.02)	(0.04)	(0.05)
$\bar{R}^2$	0.434	0.677	0.197	0.309	0.108	0.204	0.152
F-Stat	15.878	61.051	9.489	19.551	6.629	5.770	5.161
DF	5	5	5	5	5	5	5
N	164	164	164	164	164	164	164

Notes: The numbers in parenthesis are robust standard errors. The superscripts *, **, and *** denote the significance with the 5%, 1%, and 0.1% levels, respectively.

Table 3 Regressions with Solow Variables, Policy and Demographic Variables, 1970−2010

	Output Growth	A/GDP	I/GDP	S/GDP	Agriculture Growth	Industry Growth	Service Growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDI	0.162***	−0.272*	0.591***	−0.265	0.037	0.304*	0.354
	(0.04)	(0.12)	(0.17)	(0.14)	(0.04)	(0.13)	(0.24)
Initial GDP	−1.043***	−5.392***	2.763*	3.350*	−0.386	−0.317	−0.368
	(0.20)	(1.01)	(1.37)	(1.49)	(0.37)	(0.48)	(0.48)
Population	0.039	0.365	−1.576	0.923	0.094	1.060*	−0.582*
	(0.21)	(0.66)	(1.09)	(0.80)	(0.28)	(0.51)	(0.26)
Education	−0.003	0.104	0.355**	−0.346*	−0.045	0.049	−0.069
	(0.02)	(0.14)	(0.11)	(0.15)	(0.03)	(0.07)	(0.09)
Education^2	−0.002	−0.020	−0.247***	0.203*	0.020	−0.041	0.032
	(0.01)	(0.07)	(0.07)	(0.08)	(0.02)	(0.04)	(0.05)
Export		−0.068*	0.355**	−0.208**			
		(0.03)	(0.11)	(0.08)			
Import			−0.387***	0.295***		−0.051**	
			(0.11)	(0.08)		(0.02)	
FDI		0.043	−0.094*			0.424*	
		(0.02)	(0.04)			(0.20)	
Portfolio						−0.169*	
						(0.08)	
Credit		−0.073***	−0.044	0.139***			
		(0.02)	(0.02)	(0.02)			
Dev. Aid		0.414**				0.188*	
		(0.14)				(0.09)	
Life	0.150**		−0.381*				
	(0.05)		(0.16)				
Mortality	0.017*	0.055		−0.099***		0.032*	
	(0.01)	(0.03)		(0.03)		(0.02)	
Fertility	−0.495*					−1.473**	
	(0.23)					(0.54)	
$\bar{R}^2$	0.525	0.760	0.406	0.543	0.133	0.413	0.176
$\Delta\ \bar{R}^2$	0.091	0.083	0.209	0.234	0.025	0.209	0.024
F-Stat	13.644	45.780	14.173	30.937	6.559	4.266	6.061
DF	8	10	10	9	5	11	5
N	161	161	161	161	161	161	161

*Note*s: The numbers in parenthesis are robust standard errors. The superscripts *, **, and *** denote the significance with the 5%, 1%, and 0.1% levels, respectively. The four Solow variables, GDI, Education, Population, and Initial GDP, are included in all regressions regardless of their significances. For all other variables, the variables with significance level less than 10% are dropped in the final estimated equation. $\Delta\bar{R}^2$ is the difference of the $\bar{R}^2$ in this table and the $\bar{R}^2$ in the previous table.

Table 4 Summary of the Regressions with All Independent Variables

Variables	Total Output Growth	Sectorial Shift, Share	Sector Growth
Solow	GDI: ↑ Initial GDP: ↓ Population: ↓	GDI: A&S→I Initial GDP: A→S Population: S ↑	GDI: I & S ↑ Initial GDP: I ↑ Population: I & S ↓
Policy	Export: ↑ Import: ↓ FDI:↑ Portfolio: ↓	Export: A→I Import: I→S FDI: S ↑ Portfolio: I→A	Export: I & S ↑ Import: I & S ↓ FDI: I & S ↑ Portfolio: I & S ↓
	CO2: ↑	Credit: A→S Inflation: I ↑ Aid: I→A	Aid: I & S ↑
Demographic	Life: ↑ Mortality: ↑	Life: I→S Mortality: I→A	Life: S ↑ Mortality: I & S ↑ Fertility: S ↑
Geographic	E.Europe&C.Asia: ↑ Sub-Sahara: ↓ North America: ↓ Latin America: ↓	E.Asia & Pacific: A&S→I South Asia: A ↓ Sub-Sahara: A ↓ Latin America: A ↓	E.Asia & Pacific: A ↑ E. Europe & C.Asia: I&S↑ Sub-Sahara: I&S ↓ Latin America: I&S ↓
	Trans. Economies: ↓ Tropical: ↑	Latitude: I→A Landlocked: A & S→I	Trans. Economies: I ↓ Latitude: I ↓ Tropical: S ↑ Landlocked: S ↓
Institutional	Legal-German: ↑	Legal-French: A→I&S Legal-Socialist: A ↑	Legal-French: S ↓ Legal-German: I & S ↓ Legal-Scandi: I ↑ Legal-Socialist: S ↓
		Catholic: S→I	Catholic: S ↑
	Frac_Ethnic: ↓ Fuel Export: ↓	Frac_Ethnic: A→I Regulation: I→A Fuel Export: A & S→I	Regulation: S ↑ Fuel Export: I & S ↓
		Muslim: I→A Non-Fuel Export: A ↑ Frac_Language: I→A	Muslim: I & S ↓
Human Rights	Religion Freedom: ↑ Women Political: ↑	Religion Freedom: A ↓ Women Political: A&I→S Domestic Freedom: S ↑	Religion Freedom: I & S ↑ Women Political: I & S ↑ Domestic Freedom: A↓ S↑ Assembly: A ↑
	Physical Integrity: ↑↓	Foreign Freedom: I&S→A Independent Juridical: A→I Physical Integrity: A&S↑↓,I↑	Foreign Freedom: S ↑ Indep. Judiciary: A&I&S↓ Physical Integrity: I&S ↑↓
	Speech: ↓ Election: ↓ Worker's Rights: ↓ Women Econ: ↓	Speech: I→A Election: I ↓ Worker's Rights: I→A Women Econ: I & S ↓	Speech: I & S↓ Election: I & S ↓ Worker's Rights: S ↓ Women Econ: A&I&S ↓

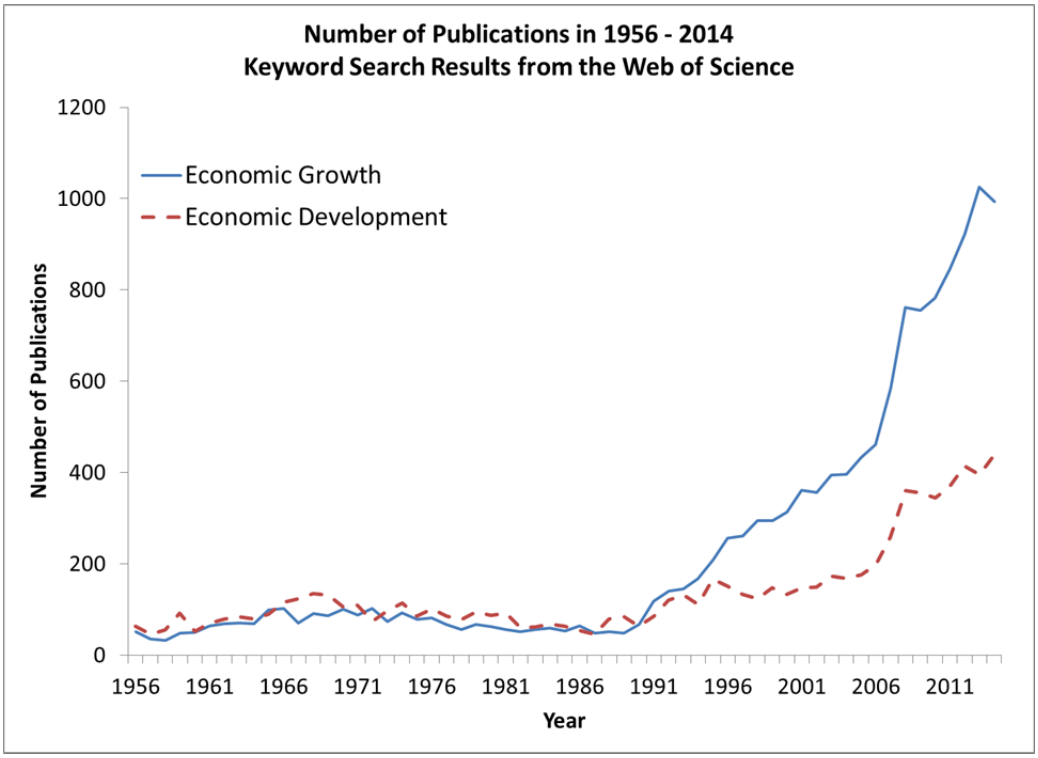
Notes: The detailed results are in Table A3 in the Appendix.

Table 5 Adjusted R^2 with Added Variables from Different Categories

Variables	Output Growth	A/GDP	I/GDP	S/GDP	Agriculture Growth	Industry Growth	Service Growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Solow	0.434	0.677	0.197	0.309	0.108	0.204	0.152
+ Policy & Demog-	0.525	0.760	0.406	0.543	0.133	0.413	0.176
+ Fixed Factors	0.621	0.838	0.576	0.686	0.189	0.552	0.532
All Variables	0.774	0.920	0.728	0.797	0.276	0.768	0.756

Notes: The adjusted R-squares are from Tables 2, 3, A2, and A3. "Policy & Demog-" includes policy and demographic variables; "Fixed Factors" includes geographic and institutional variables; and "All Variables" includes human rights variables in addition to the variables in the rest of the three categories.

Figure 1 Number of Publications on Economic Growth and Economic Development



Notes: Publications include article, book review, proceeding paper, and book chapter.

Appendix

Table A1 Variable Descriptions and Sources

Variable	Description	Source
GDP	Real GDP per worker	PWT 8.0
Sector Shares	Shares of agriculture, industry, and services	World Bank
Sector Output	Sector share times real GDP	PWT 8.0 and World Bank
GDI	Gross capital formation (% of GDP)	World Bank
Initial GDP	Initial Real GDP per worker	PWT 8.0
Population	Population growth (annual %)	World Bank
Education	School enrollment, secondary (% gross)	World Bank
Exports	Exports of goods and services (% of GDP)	World Bank
Imports	Imports of goods and services (% of GDP)	World Bank
FDI	Foreign direct investment, net inflows (% of GDP)	World Bank
Portfolio	Portfolio equity, net inflows (% of GDP)	World Bank
Credit	Domestic credit to private sector (% of GDP)	World Bank
Inflation	Inflation, GDP deflator (annual %)	World Bank
Dev. Aid	Net official development assistance and official aid received (% of GDP)	World Bank
CO2	CO2 emissions (metric tons per capita)	World Bank
Life	Life expectancy at birth, total (years)	World Bank
Fertility	Fertility rate, total (births per woman)	World Bank
Mortality	Mortality rate, under-5 (per 1,000 live births)	World Bank
E-Asia & Pacific	region: East Asia and Pacific	Global Development Network
South Asia	region: South Asia	Global Development Network
E-Europe & Cent-Asia	region: East Europe and Central Asia	Global Development Network
West Europe	region: West Europe	Global Development Network
Mid-East & N-Africa	region: Middle East and North Africa	Global Development Network
Sub-Sahara	region: Sub Sahara Africa	Global Development Network
North America	region: North America	Global Development Network
Latin America	region: Latin America and Caribbean	Global Development Network
Tropical	tropical	Global Development Network
Transi Econ	Transition Economies	Global Development Network
Latitude	Abs(latitude of capital)/90	LaPorta JLEO 1999
Landlocked	landlocked	Global Development Network
Area	area	Global Development Network
Catholic	Catholic as %pop 1980 wce95	LaPorta JLEO 1999
Muslim	Muslims as % pop 1980 wce95	LaPorta JLEO 1999
Protestants	Protestants &MgProtestantsin1980	LaPorta JLEO 1999
No_cpm80	100-Cath-Protest-Muslim in 1980	LaPorta JLEO 1999

Legal-British	legal origin: British	Global Development Network
Legal-French	legal origin: French	Global Development Network
Legal-German	legal origin: German	Global Development Network
Legal-Scandi	legal origin: Scandinavian	Global Development Network
Legal-Socialist	legal origin: Socialist	Global Development Network
Ex_Manuf	exporters of manufactures	Global Development Network
Ex_NonFuel	exporters of nonfuel primary products	Global Development Network
Ex_Fuels	exporters of fuels (mainly oil)	Global Development Network
Ex_Services	exporters of services	Global Development Network
Ex_Diversified	diversified exporters	Global Development Network
Ex_Other	not classified by export category	Global Development Network
Political Rts	Political Rights index (FW96)	LaPorta JLEO 1999
Property Rts	Property rights index	LaPorta JLEO 1999
Regulation	Regulation business index	LaPorta JLEO 1999
Frac_Ethnic	Fractionalization ethnic	Alesina JEG 2003
Frac_Language	Fractionalization language	Alesina JEG 2003
Frac_Religion	Fractionalization religion	Alesina JEG 2003
Speech (2)	Freedom of Speech	Human Rights Dataset
Reli Free (2)	Freedom of Religion	Human Rights Dataset
Ind. Jud (2)	Independence of the Judiciary	Human Rights Dataset
Elec. Self (2)	Electoral Self-Determination	Human Rights Dataset
Assembly (2)	Freedom of Assembly and Association	Human Rights Dataset
Dom. Movement (2)	Freedom of Domestic Movement	Human Rights Dataset
For. Movement (2)	Freedom of Foreign Movement	Human Rights Dataset
Worker's Rights (2)	Worker's Rights	Human Rights Dataset
Women economic (3)	Women's Economic Right	Human Rights Dataset
Women social (3)	Women's Social Rights	Human Rights Dataset
Torture	Torture	Human Rights Dataset
Killing	Extrajudicial Killing	Human Rights Dataset
Political imprison	Political Imprisonment	Human Rights Dataset
Disappearance	Disappearance	Human Rights Dataset
Physical Rights (8)	Physical Integrity Rights Index	Human Rights Dataset

Notes: For the regional variables, the dummy variables are created for each region with the West Europe excluded from the regression as the base. For legal origin variables, the British origin is excluded from the regression as the base. For the export category, not classified by export category is excluded from the regression. The dummy variables are created for each human right variable as these variables are indicators with the values of 0, 1, 2, … The higher value indicates a higher level of human rights. The numbers in the parentheses are the highest value of the indicator. The dummy variable with the indicator of zero is excluded from the regression.

Table A2 Regressions with Added Institutional and Geographical Variables, 1970-2010

	Output Growth	A/GDP	I/GDP	S/GDP	Agriculture Growth	Industry Growth	Service Growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDI	0.123**	-0.358**	0.509*	-0.372*	-0.040	0.313*	0.425*
	(0.04)	(0.12)	(0.20)	(0.17)	(0.04)	(0.13)	(0.17)
Initial GDP	-1.079***	-5.280***	0.401	4.312**	-0.271	0.524	0.191
	(0.18)	(0.98)	(1.65)	(1.34)	(0.48)	(0.76)	(0.56)
Population	-0.176	-1.407*	1.116	2.331	0.266	0.409	0.091
	(0.17)	(0.66)	(1.01)	(1.50)	(0.34)	(0.48)	(0.55)
Education	0.021	-0.001	0.236*	-0.342**	-0.040	-0.048	-0.059
	(0.02)	(0.10)	(0.11)	(0.13)	(0.04)	(0.04)	(0.06)
$Education^2$	-0.014	0.013	-0.135*	0.251***	0.004	0.018	0.019
	(0.01)	(0.06)	(0.06)	(0.07)	(0.02)	(0.03)	(0.03)
Export	0.032**	-0.083***	0.236*	-0.206**			
	(0.01)	(0.02)	(0.10)	(0.07)			
Import	-0.040**		-0.262*	0.325***		-0.071**	-0.062*
	(0.01)		(0.11)	(0.08)		(0.03)	(0.03)
FDI	0.201*				-0.021**	0.830**	0.845*
	(0.10)				(0.01)	(0.29)	(0.36)
Portfolio	-0.078*	0.018*	-0.032*	0.051**		-0.326**	-0.320*
	(0.04)	(0.01)	(0.01)	(0.02)		(0.11)	(0.14)
Credit		-0.076***		0.112***			
		(0.02)		(0.03)			
Inflation		-0.017**	0.021*	-0.018*			
		(0.01)	(0.01)	(0.01)			
Dev. Aid		0.338*	-0.271				
		(0.14)	(0.16)				
CO2				-0.773**			
				(0.29)			
Life	0.142***	0.796***	-0.822**				
	(0.04)	(0.21)	(0.24)				
Mortality	0.014	0.119**	-0.108**			0.024	0.046*
	(0.01)	(0.04)	(0.03)			(0.01)	(0.02)
Fertility				-3.337*			
				(1.52)			
E-Asia & Pacific					1.391*		-3.079*
					(0.67)		(1.34)
E-Europe & Cen-Asia	1.908***		-6.267**				
	(0.21)		(1.98)				
Sub-Sahara						-3.345**	-4.197**
						(0.99)	(1.52)
Latin America	-0.565*		-4.793*	7.669**		-1.634	-2.871**

	(0.28)		(2.09)	(2.28)		(0.83)	(1.03)
Transi. Econ	-2.356***		6.873			-2.423*	
	(0.57)		(3.49)			(1.19)	
Latitude				12.084*			
				(5.85)			
Tropical					-1.231*		
					(0.58)		
Landlocked			4.205*	-6.286***			-2.963*
			(1.67)	(1.46)			(1.22)
Muslim						-0.022	-0.062**
						(0.01)	(0.02)
Protestants		-0.058**			0.019*		
		(0.02)			(0.01)		
Legal-French		-5.558***	3.990*				
		(1.28)	(1.53)				
Legal-German					-1.294*		
					(0.60)		
Ex_Fuel			12.489**			-3.868*	
			(3.71)			(1.68)	
Ex_NonFuel		5.048***					
		(1.48)					
Political Rts		-0.976**				-0.516**	-0.572*
		(0.34)				(0.16)	(0.26)
Property Rts		-2.061**	2.210*	1.389			1.036*
		(0.65)	(0.86)	(0.80)			(0.50)
Regulation		2.113**	-2.926**				
		(0.74)	(1.01)				
Frac_Ethnic	-1.207*			8.026**			-2.945
	(0.51)			(2.82)			(1.52)
Frac_Language		6.407**	-8.960**				
		(2.34)	(2.87)				
$\bar{R}^2$	0.621	0.838	0.576	0.686	0.189	0.552	0.532
$\Delta\,\bar{R}^2$	0.096	0.078	0.170	0.143	0.056	0.139	0.356
F-Stat	.	50.265	.	62.670	14.789	6.332	3.459
DF	14	19	20	17	10	15	17
N	124	124	124	124	124	124	124

Note: See notes in Table 3.

Table A3 Regressions with All Variables by Adding Human Rights Variables, 1970-2010

	Output Growth	A/GDP	I/GDP	S/GDP	Agriculture Growth	Industry Growth	Services Growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDI	0.111***	-0.246***	0.492***	-0.359**	-0.038	0.292***	0.543***
	(0.02)	(0.07)	(0.14)	(0.12)	(0.04)	(0.06)	(0.12)
Initial GDP	-0.576**	-3.625***	1.370	3.419**	-0.256	1.706**	1.061
	(0.20)	(0.69)	(1.51)	(1.27)	(0.45)	(0.51)	(0.59)
Population	-0.513**	-0.179	-0.998	3.244***	-0.030	-1.192**	-2.879***
	(0.15)	(0.65)	(0.93)	(0.84)	(0.34)	(0.41)	(0.78)
Education	0.036*	-0.127	0.069	-0.064	-0.049	-0.016	0.056
	(0.02)	(0.09)	(0.09)	(0.11)	(0.04)	(0.03)	(0.06)
$Education^2$	-0.027**	0.055	-0.074	0.106	0.017	-0.017	-0.043
	(0.01)	(0.05)	(0.06)	(0.06)	(0.02)	(0.02)	(0.03)
Export	0.027**	-0.158***	0.191**			0.049	0.097*
	(0.01)	(0.02)	(0.07)			(0.02)	(0.04)
Import	-0.038***		-0.166*	0.124***		-0.089**	-0.152***
	(0.01)		(0.07)	(0.03)		(0.03)	(0.04)
FDI	0.144*			0.117**		0.414**	0.508*
	(0.06)			(0.04)		(0.15)	(0.20)
Portfolio	-0.061**	0.020*	-0.046**			-0.174**	-0.189*
	(0.02)	(0.01)	(0.01)			(0.06)	(0.08)
Credit		-0.046**		0.056**			
		(0.01)		(0.02)			
Inflation			0.014*				
			(0.01)				
Dev. Aid		0.173	-0.308**			0.108	0.228**
		(0.09)	(0.11)			(0.06)	(0.08)
CO2	0.085**						
	(0.03)						
Life	0.125*		-0.687**	0.280*			0.261*
	(0.05)		(0.22)	(0.12)			(0.10)
Mortality	0.017*	0.048**	-0.073*			0.023*	0.080***
	(0.01)	(0.02)	(0.03)			(0.01)	(0.02)
Fertility							1.829*
							(0.76)
E-Asia & Pacific		-8.177***	8.680***	-5.309**	1.497*		
		(1.94)	(2.23)	(1.89)	(0.70)		
South Asia		-6.512*					
		(2.75)					
E-Europe & Cen-Asia	2.771***					4.868***	4.907**
	(0.45)					(1.26)	(1.51)

Sub-Sahara	-1.617**	-8.127**			-4.185***	-4.159**
	(0.56)	(2.65)			(0.88)	(1.44)
North America	-0.867					
	(0.48)					
Latin America	-1.364***	-6.535**			-2.849***	-3.251**
	(0.34)	(2.36)			(0.79)	(0.97)
Transi. Econ	-3.862***				-6.767***	
	(0.64)				(1.81)	
Latitude		-31.423***	12.594*		-10.573***	
		(5.86)	(4.94)		(2.21)	
Tropical	1.015***					3.488***
	(0.27)					(0.94)
Landlocked		-2.104	3.652**	-4.123***		-3.333***
		(1.23)	(1.33)	(1.21)		(0.87)
Catholic			0.053*	-0.084***		0.024*
			(0.02)	(0.02)		(0.01)
Muslim		-0.100***	0.079**		-0.018*	-0.049**
		(0.02)	(0.02)		(0.01)	(0.02)
Legal-French		-4.661***	2.695*	3.289*		-1.683*
		(1.08)	(1.25)	(1.34)		(0.67)
Legal-German	-0.759*				-1.698*	-2.805*
	(0.36)				(0.74)	(1.23)
Legal-Sandi					3.149**	
					(1.15)	
Legal-Socailist		7.013**				-6.285**
		(2.49)				(1.97)
Ex_Fuel	-0.979	-8.456***	16.110***	-6.126	-5.561***	-3.828*
	(0.54)	(1.60)	(3.26)	(3.21)	(1.38)	(1.66)
Ex_NonFuel		2.835*				
		(1.20)				
Regulation		2.025**	-1.412			0.753*
		(0.65)	(0.77)			(0.38)
Frac_Ethnic	-1.009*	-6.915**		5.374*		-3.757**
	(0.41)	(2.37)		(2.44)		(1.19)
Frac_Language		8.614***	-9.987***			
		(2.04)	(2.15)			
Speeach_d1		-16.159***	14.184***		-2.891	
		(2.80)	(2.96)		(1.64)	
Speech_d2	-1.975**	-12.785**	8.390*		-8.886***	-3.164
	(0.58)	(4.18)	(3.68)		(2.17)	(1.61)
Reli. Free_d1	1.498*	-6.431*			2.955*	5.073**
	(0.73)	(2.47)			(1.38)	(1.61)
Reli. Free_d2	1.736**	-8.817***			3.220*	
	(0.57)	(2.52)			(1.27)	

Ind. Jud_d1			5.798		-1.733	-3.289*	-6.498***
			(3.00)		(1.00)	(1.50)	(1.81)
Ind. Jud_d2		-10.900***	16.436***			-2.982	-3.825*
		(2.79)	(3.71)			(1.65)	(1.92)
Elec. Self_d1	-3.121***		-7.718*			-5.864***	-6.230***
	(0.58)		(3.07)			(1.71)	(1.63)
Elec. Self_d2						4.082*	
						(1.77)	
Assembly_d1					2.302		
					(1.21)		
Assembly_d2					3.251*		
					(1.37)		
Dome. Mov_d1				14.967***	-5.013**		2.204
				(3.91)	(1.60)		(1.24)
Dome. Mov_d2				11.012**	-5.297**		
				(3.51)	(1.88)		
For. Mov_d1		10.315***		-19.519***			
		(2.83)		(3.29)			
For. Mov_d2		10.893***	-11.016***				5.564***
		(2.45)	(2.62)				(1.53)
Worker Rts_d1		8.627***					-4.516**
		(2.43)					(1.66)
Worker Rts_d2	-1.378**	16.665***	-8.284**				-6.701**
	(0.49)	(3.14)	(3.07)				(2.07)
Wom. Econ_d1	-4.017***			-11.877**		-6.481***	-3.516
	(0.81)			(4.16)		(1.55)	(1.89)
Wom. Econ_d2	-5.664***		-8.017**	-8.729	-2.874*	-9.026***	-8.059**
	(0.95)		(2.68)	(4.46)	(1.23)	(1.79)	(2.45)
Wom. Econ_d3	-3.181*			-35.028***			
	(1.37)			(9.92)			
Wom. Pol_d1	6.859***		-8.122**	32.155***		7.137***	6.834**
	(1.14)		(2.93)	(9.03)		(1.87)	(2.49)
Wom. Pol_d2	6.331***	-10.301***		33.397***		4.038**	3.157
	(1.15)	(1.97)		(9.19)		(1.43)	(1.77)
Wom. Pol_d3	5.719***	-12.916***		43.115***			
	(1.21)	(3.32)		(10.35)			
Phys. Int_d1	-5.689***				-3.388	-11.991***	-17.382***
	(1.09)				(1.87)	(2.91)	(4.56)
Phys. Int_d2				-23.650***			8.394*
				(6.85)			(3.19)
Phys. Int_d3	3.987**		14.627*	-11.962		15.146***	
	(1.32)		(5.77)	(6.14)		(3.08)	
Phys. Int_d4	-3.081***	-10.478***		11.414**		-3.795*	-7.988**
	(0.89)	(2.96)		(3.56)		(1.78)	(2.43)

Phys. Int_d5			17.773***	-21.026***			
			(4.70)	(5.74)			
Phys. Int_d8		7.866**	9.724*	-12.508**			
		(2.71)	(4.21)	(4.30)			
$\bar{R}^2$	0.774	0.920	0.728	0.797	0.276	0.768	0.756
$\Delta\ \bar{R}^2$	0.153	0.082	0.152	0.111	0.087	0.216	0.224
F-Stat	.	63.267	15.409	53.710	6.128	.	5.466
DF	34	37	33	29	13	34	42
N	123	123	123	123	123	123	123

Note: See notes in Table 3.