Sector Growth and Convergence in Aggregate Agriculture, Manufacturing, and Services

---

A THESIS

Presented to

The Faculty of the Department of Economics and Business

The Colorado College

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Arts

By

Sumner Crosby

April 2016

Sector Growth and Convergence in Aggregate Agriculture, Manufacturing, and Services

Sumner Crosby

April 2016

Mathematical Economics

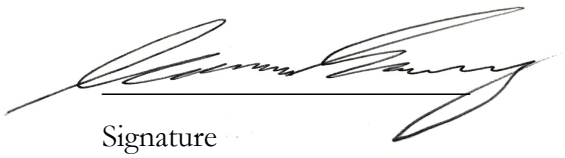
Abstract

Currently the richest countries of the world sustain an income almost seventy times that of the poorest ones. Recent literature, such as Eichengreen and Gupta (2009) and Rodrik (2012), suggest that productivity is an important determinant of growth and may explain why some nations are not catching up in the long-run, especially at the sector level. The topic of sectoral value convergence, however, has not been an area of much study. Using time series data on between 56 to 111 economies, this paper finds that absolute convergence occurred only in the manufacturing and services sectors from 1980 to 2010. When conditioned upon human capital, political infrastructure, and a number of sector specific determinants, convergence occurred across countries in agriculture, manufacturing, and services. In addition, increases in human capital are found to improve convergence effects in all three sectors.

KEYWORDS: Agriculture, Manufacturing, Services, Growth, Convergence, Productivity

JEL Code: N1, O1, O2, O3, O4

ON MY HONOR, I NEITHER GIVEN NOR RECEIVED UNAUTHORIZED AID ON THIS THESIS



Signature

TABLE OF CONTENTS

ABSTRACT ii

INTRODUCTION 1

RELEVANT LITERATURE 2

THEORETICAL FRAMEWORK 5

DATA AND EMPERICAL METHODOLOGY 6
- Data 6
- Empirical Methodology 11

RESULTS 13
- Agriculture Sector 13
- Manufacturing Sector 15
- Services Sector 16
- Policy Implications 18

CONCLUDING REMARKS 19

REFERENCES 20

1. Introduction

A central question of economics is why some countries are richer than others. Over the last century, the income gap between the lowest and highest income nations has grown exponentially, with the United States and its developed brethren continuing to see strong economic success while many African and Asian countries struggle to create reliable sources of growth. Hultberg et. al. (2001) finds that in the early 2000s, high income nations had a per capita income about thirty-five times that of lower income nations, and based upon the World Development Indicators, today the richest countries of the world enjoy an income almost seventy times that of the poorest ones. Understanding what drives growth in developing and developed countries is an important topic of economic study and is crucial to closing the ever-widening income gap between rich and poor nations.

According to neoclassical growth theory, such as Solow (1956), all countries are expected to converge towards each other on a unique long-run growth path. More specifically, due to diminishing returns on marginal productivity of capital, poorer countries will typically grow at a faster rate than richer ones. Even though neoclassical growth theory predicts that convergence should occur over time, past empirical studies show mixed results at both the aggregate and sector levels. Kyriacou (1991) finds evidence of conditional convergence with health and education factors while Lucas (1988) indicates that convergence effects are weak and heterogeneous factors led to divergence amongst some nations. Barro (1991) links cross-country differences in GDP per capita growth to human capital, a well-known determinant of labor productivity.

Sector convergence of labor productivity is also a topic of much economic discussion, and Clark (1940), Lewis (1954), and Martin and Mitra (1999) suggest that differences in labor productivity are a significant explanatory factor of both structural transition from agriculture to more capital-intensive industries and differences in sector growth across nations. While there is extensive literature on structural transition and convergence on the aggregate and sector levels, there are no studies that include analysis of all three main sectors related to growth: agriculture, manufacturing, and services. This study aims to fill the gap in economic literature and provide new insight into why some countries may not be catching up to others.

This paper investigates the extent that convergence occurred across countries in the value of agriculture, manufacturing, and services as a percentage of GDP from 1980 to 2010. In addition, it evaluates the role that a number of human capital, political, and sector specific factors play in explaining cross-country convergence effects. The main finding of this paper is that there is some absolute and conditional convergence across nations in agriculture, manufacturing, and services from 1980 to 2010. Similar to previous studies, this paper reveals that the manufacturing and service sectors experienced absolute convergence while the agriculture sector did not. When worker productivity, political institutions, and a few sector specific determinants are controlled for, all three sectors experienced significant cross-country conditional convergence as well.

The analysis suggests that domestic sector values are indeed moving towards each other in the long-run. Further, improving worker productivity can increase the speed at which nations reach a more optimal long-run sector value. This study shows that political structure plays a significant role in explaining differences in manufacturing and services growth across nations. It also shows that areas of the world with more arable land, such as the United States, parts of Europe, and Australia, tend to be experiencing lower agricultural growth rates, which could indicate that these areas contain more developed economies. Contrary to some empirical studies, physical capital formation was not found to be a reliable predictor of sectoral growth distribution.

The remainder of the paper is as follows. Section 2 contains a review of previous empirical studies and relevant literature on the topic of sectoral convergence and productivity. Section 3 outlines the theoretical framework for the paper and discusses the dynamics of the factor inputs. Section 4 introduces the data series that are used in the empirical study and provides preliminary statistical motivation for the paper. It also provides the empirical methodology for the regression models. Section 5 outlines and presents the results of the paper while making some conclusions about possible policy implications. Section 6 concludes.

2. Relevant Literature

Literature on convergence and sectoral development involves a few main areas of study. Evidence of conditional income per capita convergence is widely accepted, and empirical studies such as Barro (1991), Barro and Sala-Martin (1991), and Kyriacou (1991) indicate that countries with a lower initial value of GDP per capita have experienced varying amounts of convergence, especially

when conditioned upon human capital. Lucas (1988) finds an opposing result and concludes that countries may not converge over time due to differences in comparative advantage and capital endowments. However, most economists do agree that increases in health and education infrastructure tend to lead to growth. These studies also suggest that there are a number of other heterogeneous factors that play an important role in explaining differences in long-run growth across nations, such as capital and technology accumulation, political infrastructure, and productivity of labor. In order to better understand what drives growth, economists closely examine the role that three main sectors play in determining domestic development.

The agriculture sector is generally regarded as being less preferable as a nation develops. The Ricardian Model suggests that there is little to no agriculture productivity growth due to a fixed level of technology, but studies such as Hayami and Ruttan (1985), Martin and Mitra (1999), and Matsuyama (1990) show that as technology improves, so does agriculture growth. Coupled with increases in human capital, technology accumulation will lead to better agriculture productivity. Authors, such as Lewis (1954) and Wichmann (1996), suggest that productivity growth is crucial to increasing labor mobility to other industries, and the movement of labor away from agriculture stimulates industrialization and promotes long-run growth. However as Poonyth et. al. (2001) shows in their study of South Africa, improving agriculture productivity is still essential to many developing economies and is required before industrialization can occur. There is also some evidence of agriculture productivity convergence, as indicated by Poudel, Paudel, and Zilberman (2011), but according to their study this effect only occurred in developed nations.

Like the agriculture sector, there is a large number of studies regarding the role that aggregate and individual manufacturing industries play in explaining long-run growth trends. Empirical studies by Clark (1940) and Chenery (1960) suggest that as a nation develops, they tend to move from agriculture to manufacturing as a means to stimulate income per capita growth, and this process is known as structural change or structural transition. As demonstrated by Syrquin (1986), nations experience faster growth of productivity in the manufacturing sector than in the agriculture sector. This occurs through a range of methods including the exploitation of comparative advantage and foreign direct investment to improve manufacturing technology and infrastructure. Recent literature on manufacturing growth focuses on productivity convergence, but the results are mixed. Dollar and Wolff (1988) and Rodrik (2012) find strong aggregate convergence results, but the effect is weakened when individual industries are observed. Hultberg et. al. (2001) find that productivity convergence is

reliant on a number of heterogeneous factors such as capital endowment and bureaucratic efficiency. Broadberry (1993) and Bernard and Jones (1996a,b) suggest that convergence of GDP per worker must have occurred through trends in other sectors than manufacturing or through compositional effects.

An increasing number of development economists emphasize the importance of the services sector to domestic growth, especially in developing nations. Studies by Hoekman and Mattoo (2008) and Mattoo, Rathindran, and Subramanian (2006) indicate that growth in the services sector can be linked to increases in GDP per capita and decreases in population growth rates. Some Asian nations, such as India, are a shining example of this predicted sectoral shift. In recent years, as shown by Dasgupta and Singh (2005), India has seen massive increases in the IT services industry, and these improvements to the services sector have had spillover effects to other sectors, such as manufacturing and agriculture. This empirical result is confirmed by Lee and McKibbin (2014), who find that faster productivity growth in the service sector in Asia benefitted all sectors eventually. Similarly, Eichengreen and Gupta (2009) suggest that there is two-waves of growth within the services sector that directly affect growth in agriculture and manufacturing. These results conflict with the findings of Clark (1940), Fisher (1939), and Chenery (1960), who put little emphasis on the importance of services to growth. However, due to improvements in telecommunications and technology since 1980, the assumptions made in these studies have lost some of their validity in recent years. Empirical work points to a number of factors that influence differences in services growth across countries, and Hoekman and Mattoo (2008) and Eichengreen and Gupta (2009) both point to political institutions, openness to trade, and sector regulation as crucial to promoting services growth in developing nations.

While the last century provides a large number of papers that investigate a range of topics on convergence, there seems to be a gap in the literature when it comes to sectoral value convergence. As opposed other sector specific literature which tends to focus on productivity development and technology accumulation, this paper is the first to closely analyze convergence of sector value. It comments on whether or not the value of agriculture, manufacturing, and services reach a general optimal level in the long-run and makes a significant, new contribution to economic literature.

3. Theoretical Framework

Following endogenous growth models created by Lucas (1988) and Romer (1990), this paper aims to continue the notion that due to diminishing returns of capital, richer countries with a higher capital endowment will generally have a lower marginal product of capital than poorer countries, thus allowing poorer countries to potentially catch up in the long-run. Neoclassical growth theory predicts that final output *Y* will be a function of total factor productivity *A*, labor *L*, and capital *K*. A simple functional form for output will be given by the following Cobb-Douglas production function:

(1) $$Y(A, L, K) = A(L)^{\alpha}(K)^{1-\alpha}$$

However, neoclassical theory and empirical studies such as Barro (1991) suggest that differences in total factor productivity explain why some developing countries are struggling to catch up to developed ones. The theoretical models introduced by Lucas (1988) and Romer (1990) identify human capital and technology accumulation as the most important determinants of differences in growth across countries, as they influence both labor and capital productivity. Political stability and infrastructure, along with a number of other factors, also influence the productivity of labor and capital accumulation, so a control for other heterogeneous domestic factors is included in the model. In the model, aggregate output *Y* is expressed as a function of labor L, physical capital *K*, human capital H_Y, and a number of other factor inputs *Z*. The augmented production function is as follows:

(2) $$Y(H_Y, Z, L, K) = Z^{\alpha}(H_Y L)^{\beta}(K)^{1-\alpha-\beta}$$

(3) $$H_Y{}' = \theta(1-\rho)H_Y$$

Equation (3) defines human capital in the future $H_Y{}'$, where $\theta > 0$ and is an exogenous parameter that captures the efficiency of the human capital accumulation technology. $(1 - \rho)$ is an exogenous parameter that denotes the units of time used for human capital accumulation such as education and on-the-job training. The higher the productivity of training, the more it increases the marginal product of labor and hence income per capita growth.

Equations (2) and (3) indicate that only by holding human capital constant at an initial level will countries be able to converge on the long-run growth path. While empirical studies such as Barro (1991) and Kyriacou (1991) find that convergence occurs, theory suggests that only countries which

are similar in terms of productivity and other factor inputs may be able to converge towards each other. The model set up by Lucas (1988) implies that differing levels of initial human capital will not change the long-run growth path, but instead create a level effect, making cross-country convergence impossible in some situations. Similarly, Romer (1990) states that technology is crucial to accounting for differences in growth across countries, but due to large technology gaps across nations, some developing countries are having trouble catching up to more developed ones. Technology within neoclassical growth theory is assumed to be equal, but in the real world all countries do not have access to the same technology and R&D. Barriers in technology adoption arise due to labor unions and international political and trade policy, and this causes total factor productivity to differ from nation to nation. The theories outlined in Equations (2) and (3) suggest that differences in total factor productivity and other heterogeneous factors Z^{α} cause steady state capital per worker and income per worker to differ over time, and this potentially promotes divergence across nations.

(4) $$lnY = \alpha lnZ + \beta lnH_Y L + (1 - \alpha - \beta) lnK$$

When the natural log is taken of both sides of Equation (2), the result takes a more functional form. Equation (4) is a log-linear formulation of the Cobb-Douglas production function that serves as the theoretical basis for the empirical methodology. The growth in output is regressed directly on the percentage growth in labor and capital, as well as the growth in a number of other factors such as human capital and the initial value of each sector as a percentage of GDP. An augmented version of Equation (4) is revisited in the following section to set up a model to examine the null hypothesis of no convergence across nations.

4. Data and Empirical Methodology

4.1 Data

The data series in this study are drawn primarily from the World Development Indicators (WDI) dataset. This data is compiled quarterly by officially recognized sources and is considered to be one of the largest and most complete international data sets available. It provides data on 214 economies from 1960 to 2015 and covers most of the data needs of this paper's analysis. The data series for political controls are drawn from Robert E. Keefer's Database of Political Institutions. Developed in 2012 and updated in 2013, this data set includes metrics on a number of political factors

and indicators spanning from 1975 to 2012 and provides information on 169 economies. More background on political variable collection and definitions can be found within the Database Codebook.[1]

For all countries in the three named sectors, the time period studied is 1980 to 2010. Due to missing or incomplete data series, the present study has a unique subset of countries for each sector analysis, ranging from 56 to 111 countries. All of the empirical models for absolute and conditional convergence contain two inputs from the WDI database, the first of which is 1980 Sector Value as a percentage of GDP. Second, a thirty-year average sectoral value growth rate is calculated using times-series data from 1980 to 2010. The models for conditional convergence contain a number of other human capital and sector specific inputs from the WDI database. Following the theoretical and empirical models highlighted in Barro (1991) and Lucas (1988), each conditional model utilizes two human capital indicators. 1980 Secondary School Enrolment serves as a proxy for education while 1980 Life Expectancy acts as a control for health infrastructure. 1980 Arable Land as a percentage of total land area is included in the analysis of the agriculture sector as a control for domestic land quality. 1980 Gross Fixed Capital Formation controls for cross-country differences in initial physical capital levels and investment within the manufacturing and services sectors. These data series are all obtained from the World Bank dataset listed above.

The conditional convergence models also include two political indicators from the Database of Political Institutions; EIEC and EXECRLC. EIEC is a measure of how executive bodies obtained power, ranging from 1 to 7. Parties or people who obtained power through force or a conflict receive a score of 1, while competitively elected prime ministers get 6 or 7. EXECRLC is a control for political party orientation where a nation can receive 0, 1, 2, or 3, with the number indicating respectively no information available, right-wing, center, or left-wing. More information on the determinants of political score can be found in the database handbook cited below.

Table I highlights some interesting basic statistics on the variables listed above. Over the thirty-year span, both the agriculture and manufacturing sectors experienced negative average global growth rates. The services sector, however, had positive global growth throughout the period, and the 1990s

[1] Keefer, P. (2012, December). DPI2012 Database of Political Institutions: Changes and Variable Definitions. Retrieved from http://siteresources.worldbank.org/INTRES/Resources/469232-1107449512766/DPI2012_Codebook2.pdf

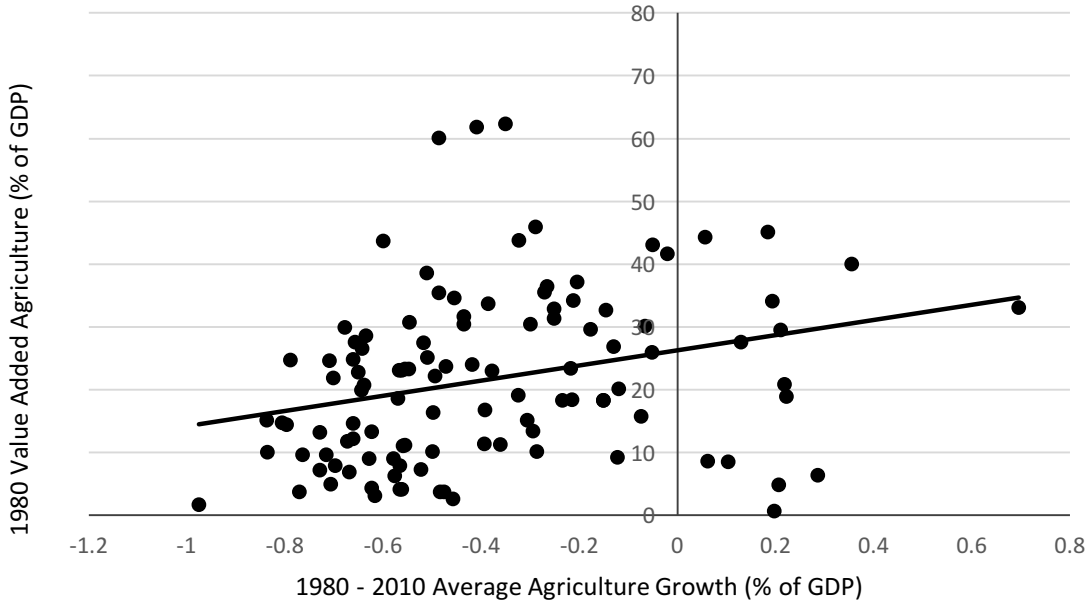
especially were a time of increased services growth. Since 1980, global agriculture value has declined at a faster rate as nations have developed and moved away from agriculture as a pillar of growth, but due to increases in farming techniques and productivity, a higher percentage of global land was arable in 2010 than in 1980. Average global life expectancy rose about five years over the thirty-year period, and Enrolment in Secondary Education saw global increases from 1980 to 2010, but some nations are still far behind due to some very low observations and a large standard deviation of the data-series. Similarly, physical capital formation seems to have increased over the sample period, almost doubling in each decade since 1980, but there is still a large gap between rich and poor countries based upon high standard deviation of the capital distribution.

Table I. – Descriptive Statistics of the Variables

					Averages		
Variable	Minimum	Mean	Maximum	Std. Dev.	1980-1990	1990-2000	2000-2010
1980-2010 Growth Rates							
Agriculture Sector	-0.975	-0.390	0.696	0.312	-0.022	-0.208	-0.246
Manufacturing Sector	-0.671	0.042	2.147	0.543	-0.246	-0.014	-0.168
Services Sector	-0.501	0.237	1.367	0.357	0.063	0.103	0.024
Input Variables							
Life Expectancy, (years)	27.739	61.759	76.847	10.274	63.675	66.051	68.685
Enrolment in Secondary Education, (number)	998	1.13e+07	2.94e+08	.3120919	1.01e+07	1.22e+07	1.54e+07
Arable Land (% of Total Area)	.0431	12.844	70.070	13.145	12.825	13.649	13.763
Gross Fixed Capital Formation (US $)	1.01e+07	2.28e+10	6.72e+11	7.80e+10	1.25e+11	2.08e+11	3.45e+11

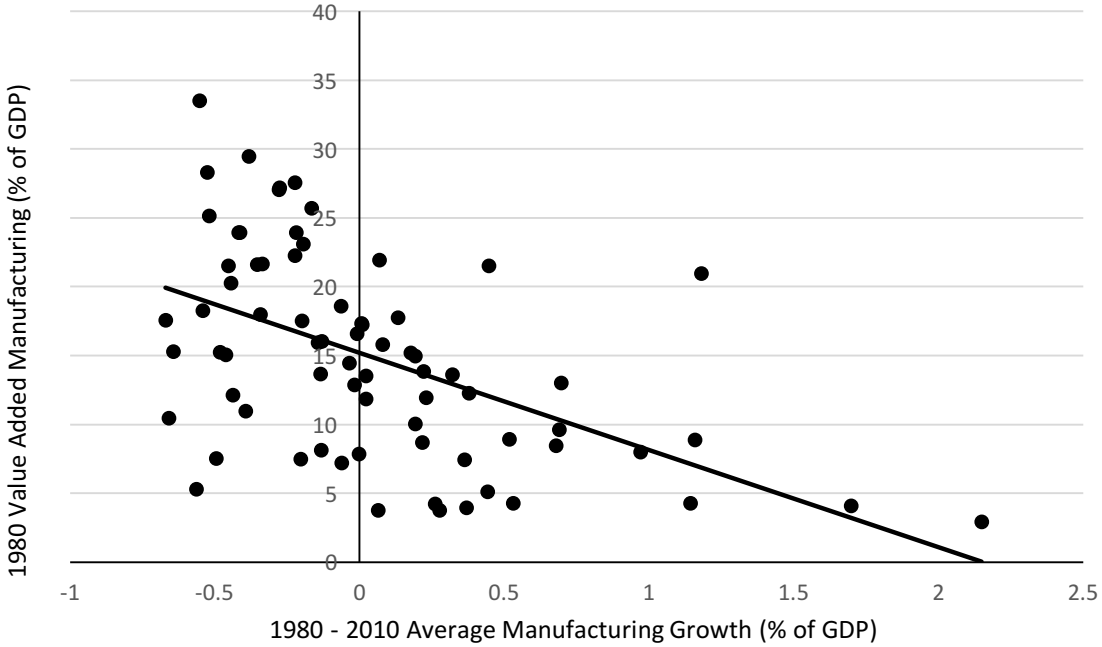
Like Table I, Figures I, II, III, and IV illustrate some of the central results of the World Bank data series and help to place the paper in perspective. Figures I, II, and III show the relationship between 1980 Value Added of each sector and 1980-2010 Average Sector Growth. Figure IV demonstrates how sector share as a percentage of GDP has changed over time for Low, Middle, and OECD countries. Figure I, where each dot stands for a particular country during the sample period, does not present an absolute cross-country convergence result for the agriculture sector. There was not a significant tendency for countries with a higher initial value of agriculture to experience lower long-run growth rates, and this is demonstrated by a positive slope of the fitted line.

Figure I. – 1980 Value of Agriculture vs. 30 Year Agriculture Growth



Note: The variable on the horizontal axis is a calculated average growth rate of agriculture from 1980 to 2010. The data was gathered from the WDI World Bank data series.

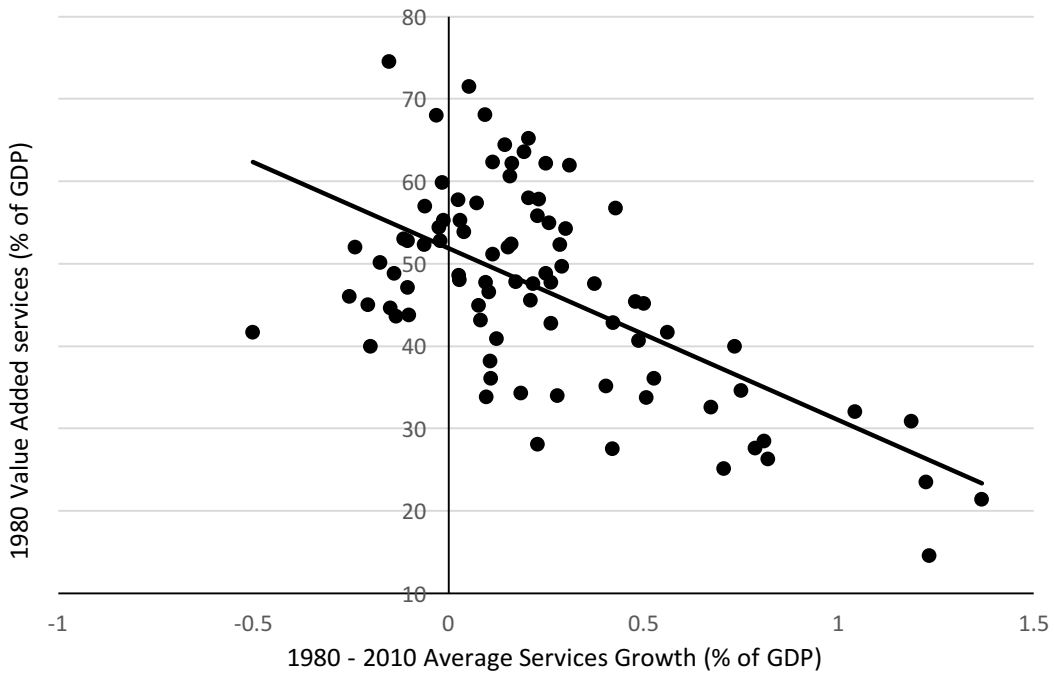
Figure II. – 1980 Value of Manufacturing vs. 30 Year Manufacturing Growth



Note: The variable on the horizontal axis is a calculated average growth rate of manufacturing from 1980 to 2010. The data was gathered from the WDI World Bank data series.

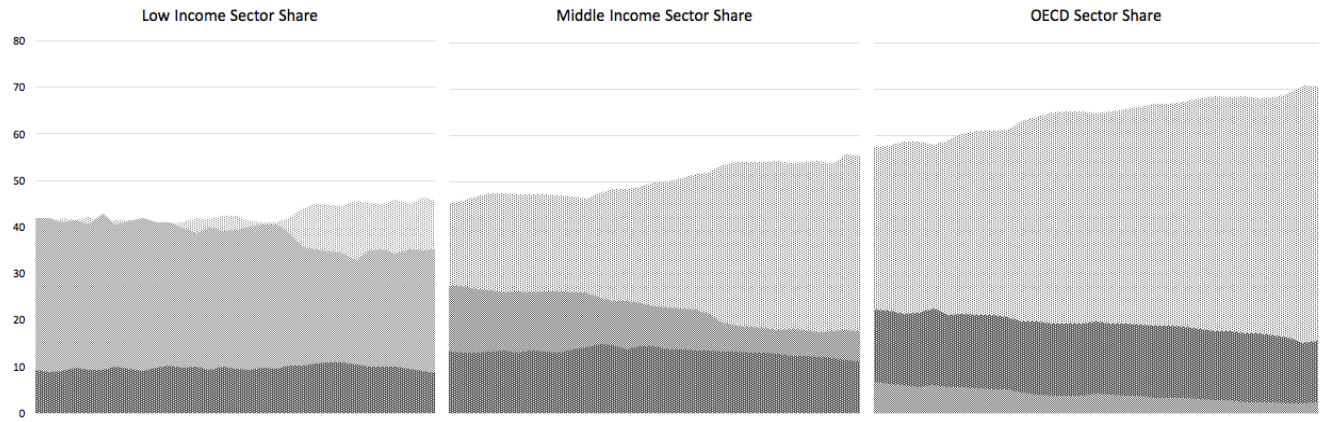
Figure II depicts the confirmation of absolute convergence effects within the manufacturing sector from 1980 to 2010. Each dot represents aggregate manufacturing levels in a specific nation, and the data shows that without conditioning upon productivity or other exogenous factors, over time economies that start at a lower initial value of manufacturing as a percentage of GDP will tend to catch up to those with a higher initial value. Similarly, Figure III indicates the same result occurred in the services sector from 1980 to 2010. The fitted line has a negative slope, suggesting that during the sample period nations with a lower initial value of services as a percentage of GDP were catching up to those with a higher initial sector value. The relationship highlighted in Figure III seems to contain the strongest evidence of unconditional convergence of the three sectors, which is examined later in the paper.

Figure III. – 1980 Value of Services vs. 30 Year Services Growth



Note: The variable on the horizontal axis is a calculated average growth rate of services from 1980 to 2010. The data was gathered from the WDI World Bank data series.

Figure IV. – Income Level Sector Share from 1980 to 2010



Note: Light, medium, and dark grey areas represent services, agriculture, and manufacturing as a percentage of GDP respectively. The variable on the horizontal axis is Time Period (years), spanning from 1980 to 2010. The variable on the vertical axis is sectoral share (% of GDP) ranging from 0 to 80 percent. The data is drawn from the WDI World Bank data series, (see below).

Figure IV suggests two main results. First, over the 30-year sample period sectoral shares tended to follow average growth paths similar to those suggested by the literature. The data indicates that the value of agriculture as a percentage of GDP decreased from 1980 to 2010 globally. According to Wichmann (1996), Martin and Mitra (1999), Gollin, Parente, and Rogerson (2002), and Lewis (1954), this is the natural progression of nation's economies. These authors find that movement away from agriculture will induce structural shifts in the economy towards other industries. The time-series data confirms this theory, with the value of manufacturing and services increasing as the value of agriculture as a percentage of GDP decreased.

Second, the time-series data in Figure IV indicates that income level plays an important role in sector share. In low income nations, the value of agriculture and services as a percentage of GDP was fairly similar from 1980 to 2010, but the services sector in OECD countries dwarfed the agriculture sector in comparison. This seems to agree with the empirical findings of Eichengreen and Gupta (2009) and supports the development theory suggested by Clark (1940) and Fisher (1939). In middle income nations, the value of services as a percentage of GDP was about twice as much as the agriculture sector in 1980, but grew to almost triple it by mid to late 2000s. The time-series data also shows that as income per capita increased, the initial and long-run value of manufacturing as a percentage of GDP increased as well.

Figure IV highlights many of the findings of previous empirical and theoretical studies, but it also serves as motivation for this paper. While it shows that as nations develop and increase national income per capita there are certain trends in sector value transition, Figure IV stimulates this paper with the question of whether or not these countries are actually moving towards one another. Further, it asks if there is a conceivable optimal long-run value of agriculture, manufacturing, and services and if nations are moving towards it. To investigate these questions, this paper runs a number of estimations for sector convergence.

4.2 Empirical Methodology

This paper employs a number of regression models to investigate absolute and conditional cross-country convergence effects within each sector from 1980 to 2010. All of the models use an Ordinary Least Squares (OLS) estimation approach. In each regression, the β_1 coefficient tests the hypothesis of convergence, and if $\beta_1 < 0$ and is significant, the model suggests that sectoral convergence occurred from 1980 to 2010 in a cross section of nations. The regression model for the agriculture, manufacturing, and services sectors is:

(5)
$$Y_i = \beta_0 + \beta_1 X_{1i} + \Omega Z_i + \varepsilon_i$$

$$\varepsilon_i \overset{iid}{\sim} N(0, \sigma_\varepsilon^2)$$

where for each country (i), Y_i, X_{1i}, $\mathbf{\Omega}$, Z_i, and $\boldsymbol{\varepsilon}_i$ denote respectively 1980-2010 Average Value of Sector Growth (% of GDP), 1980 Value of Sector (% of GDP), vector of Control Coefficients, vector of Controls, and the error term. Z_i is a vector of the control inputs for each conditional convergence model. $\mathbf{\Omega}$ is a vector that contains the control coefficients which will indicate the role that each input plays in explaining differences of sector growth across nations.

For estimations of absolute convergence, the vector of Controls is an empty vector. For the model of conditional convergence within the agriculture sector, the vector of Controls contains X_{2i}, X_{3i}, and X_{4i}. For each country (i), these values denote respectively 1980 Secondary Education Enrollment, 1980 Life Expectancy, and 1980 Arable Land (% of total land area). The vector of Controls for the model of conditional convergence in the manufacturing sector contains a number of physical capital accumulation and political inputs, in addition to the human capital controls used in the agriculture sector model. For each country (i), X_{2i}, X_{3i}, X_{4i}, X_{5i}, and X_{6i} denote respectively 1980

Life Expectancy, 1980 Secondary Education Enrollment, 1980 Gross Fixed Capital Formation, 1980 EXECRLC, and 1980 EIEC.

The conditional estimation of convergence within the services sector contain two models; Conditional_1 and Conditional_2. Conditional_1 employs a model similar to that of the manufacturing sector. The vector of Controls contains X_{2i}, X_{3i}, X_{4i}, X_{5i}, and X_{6i}. For each country (i), these values denote 1980 Life Expectancy, 1980 Secondary Education Enrollment, 1980 Gross Fixed Capital Formation, 1980 EXECRLC, and 1980 EIEC respectively. Conditional_2 is almost identical to Conditional_1 but omits X_{4i}, or Gross Fixed Capital Formation, from the vector of Controls.

5. Results

Table II contains the regression estimates of the significant convergence coefficient, β_1, and indicates a number of important results about the hypothesis that from 1980 to 2010 nations with a lower initial value of agriculture, manufacturing, or services will eventually catch up to those with higher initial sector levels. Table II demonstrates the difference between absolute and conditional convergence estimations within each sector and the role that a number of social, physical, and political factors play in the conditional convergence hypothesis. The pattern of coefficients suggests that conditional convergence and some absolute convergence has occurred within each sector during the sample period. In addition, some of the proxies for human capital and political institutions are found to be significant.

5.1 Agriculture Sector

Table II indicates a number of important results about the agriculture sector. As demonstrated in Figure I, there were no significant absolute convergence effects from 1980 to 2010, but when conditioned on three human capital and quality of land factors, there does seem to be cross-country conditional convergence in the agriculture sector during this period. From 1980 to 2010, nations with a higher initial value of agriculture as a percentage of GDP tended to experience negative agriculture growth. Hence, as nations became more developed they tended to have a lower value of agriculture as a percentage of GDP. This strong convergence result agrees with empirical studies performed by Martin and Mitra (1999) and Gollin et. al. (2002) and structural change theory explained by Clark (1940) and Fisher (1939).

Table II. – OLS Regression Results of Absolute and Conditional Convergence Estimations

	Agriculture Sector		Manufacturing Sector		Services Sector		
Inputs	Absolute	Conditional	Absolute	Conditional	Absolute	Conditional$_1$	Conditional$_2$
Convergence Coefficient							
1980 Sector Value (% of GDP)	0.00654 (0.00224)	-0.0067* (0.00229)	-0.0378* (0.00828)	-0.0206** (0.01055)	-0.0180* (0.00289)	-0.0221* (0.00374)	-0.0248* (0.00261)
Productivity							
Life Expectancy, (years)		-0.0236* (0.00370)		0.0029 (0.00807)		0.0151* (0.00406)	0.0174* (0.00265)
Enrolment in Secondary Education, (number)		-1.37e-09* (3.24e-10)		1.02e-08** (5.21e-09)		-8.60e-09 (2.79e-08)	1.65e-09 (1.39e-08)
Land Use							
Arable Land (% of Total Area)		-0.0027* (0.00151)					
Physical Capital Accumulation							
Gross Fixed Capital Formation (US $)				-6.69e-13 (6.26e-13)		4.48e-13 (6.96e-13)	
Political Indicators							
EIEC				-0.0197 (0.04088)		-0.0122 (0.0157)	-0.0202 (0.01391)
EXECRLC				-0.1044* (0.02858)		0.0403 (0.0264)	0.0432** (0.02452)
Adj. R^2	0.050	0.341	0.257	0.175	0.367	0.419	0.583
Number of Obs.	111	90	73	56	87	63	69
F-stat	8.51*	*N/A*	20.89*	*N/A*	38.67*	*N/A*	22.01

Note: * and ** imply significance from zero to 5 percent and 10 percent, respectively. The robust standard error is in parenthesis.

All three human capital and arable land estimates appear to be highly significant at the ninety percent level or higher. Table II highlights the importance of worker productivity in agriculture convergence and shows that human capital, a proxy for worker productivity, had a negative relationship with long-run growth during the sample period. This result agrees with other empirical studies in that increases in productivity will result in a decrease in agricultural dependence, or in this case, the value of agriculture as a percentage of GDP (Wichmann 2003, Clark 1940, Fisher 1939, and Barro 1991). As a nation's workers become more productive, they tend to move away from agriculture as a means to stimulate growth, and this will open up labor to enter other sectors. This structural transition is important to long-run GDP per capita growth in developing countries, but in some cases until productivity is increased, the agriculture sector remains crucial to GDP per capita growth.

Similar to Martin and Mitra (1999), the amount of arable land was also found to be significantly related at the ninety percent level to agricultural growth from 1980 to 2010. Interestingly, as the amount of arable land as a percentage of total land area increased, long-run agricultural growth rates decreased by a coefficient of -0.00272. This result suggests that areas with larger amounts of arable land, such as North America, Australia, and parts of Europe, may tend to be more developed, and hence have lower agricultural growth rates. These areas also industrialized earlier, so their value of agriculture as a percentage of GDP will be lower than those who are less industrialized or unindustrialized. In addition, by 1980 many of the sample nations may have already transitioned away from a dependence on agriculture, so this could be a reason for a lack of absolute convergence.

While the regression model may seem to explain significant convergence and indicator effects, the results need to be put in context. Due to the lack of a F-statistic in the regression output and a low adjusted R^2 statistic, the model does not seem to be a very robust fit to the data. These values also indicate that 1980 Value of Agriculture as a percentage of GDP does not reliably predict Average 1980-2010 Value of Agriculture Growth. That being said, the conjectures stated above will still be used to make a number of conclusions about conditional convergence within the agricultural sector and structural transition in developing and developed nations from 1980 to 2010.

5.2 Manufacturing Sector

There are a number of important results to note from Table II about the cross-country absolute and conditional convergence estimations from 1980 to 2010 within the manufacturing sector. There was significant absolute convergence within the aggregate manufacturing sector from 1980 to 2010 in a sample of 74 countries. Without conditioning manufacturing growth on worker productivity, capital formation, or political factors, countries with lower initial levels of manufacturing as a percentage of GDP seem to be catching up to those with more developed manufacturing sectors. Despite the fairly low adjusted R^2 value, the fit of the data to the model is fairly robust due to the significant f-statistic. This relationship is highlighted above in Figure II.

Table II shows that when constrained by human capital, political practices, and gross capital formation, there was conditional cross-country convergence occurring in the manufacturing sector from 1980 to 2010. The convergence coefficient is significant at the ninety percent level, suggesting

that during the sample period there was an inverse relationship between initial value of manufacturing as a percentage of GDP and long-run average value of manufacturing as a percentage of GDP growth. The low adjusted R^2 value and lack of a f-statistic output indicates that the fit of the data to the model is not very robust. While Initial 1980 Value Added of Manufacturing (% of GDP) does not seem to reliably predict 1980-2010 Average Manufacturing Growth, the relationship becomes stronger when some changes are made to the model.

Previous empirical studies such as Rodrik (2012) and Dollar and Wolff (1993) indicate that productivity is an important driver of manufacturing convergence, and this paper confirms their findings. Enrolment in Secondary Education, an indicator of human capital, is shown to be positively correlated with growth at a ninety percent confidence level, suggesting that increases in worker productivity led to faster manufacturing growth from 1980 to 2010. However, Life Expectancy was not found to play a significant role in predicting convergence within the manufacturing sector across countries. Contrary to Harrigan (1995) and Hultberg. et. al. (1998), who use physical capital as an input of manufacturing convergence, in this study Gross Fixed Capital Formation was not a significant input of manufacturing convergence from 1980 to 2010. This result suggests that physical capital endowment was not very important in explaining trends of convergence in aggregate manufacturing industries, but due to the increased importance of technology accumulation in manufacturing productivity since 1980, this result makes theoretical sense.

Table II also suggests that EIEC, a measure of how executive bodies obtained power, was not significantly related to long-run manufacturing convergence. It did, however, agree with Hultberg et. al (2001) that political institutions and bureaucracy efficiency are important determinants of manufacturing growth. EXECRLC, a control for party orientation, was found to have a negative and significant coefficient at the ninety-five percent level. This result suggests that during the sample period the more left-wing and socially oriented an executive party was, the slower the value of manufacturing as a percentage of GDP grew. Theory would state that manufacturing practice is reliant on government policy and infrastructure, and this study seems to serve as confirmation.

5.3 Services Sector

Similar to the manufacturing sector, the value of the services sector as a percentage of GDP experienced absolute convergence from 1980 to 2010, as demonstrated in Figure III. Without

conditioning upon cross-country heterogeneity factors, during the sample period nations with a lower initial value of services as a percentage of GDP were catching up to those with higher initial values. Table II also suggests there were convergence effects once the model is conditioned upon productivity, capital accumulation, and political institutions. From 1980 to 2010, as a nation's worker productivity increased and developed, the value of services as a percentage of GDP went up. This strong convergence result agrees with empirical studies performed by Eichengreen and Gupta (2009) and structural change theory explained by Clark (1940), Fisher (1939), and Hoekman and Mattoo (2008).

As shown in Table II, the results for $Conditional_1$ indicate that the fit of the data to the model is not very robust. The adjusted R^2 value is 0.419 and there was no reported f-statistic, so the conclusions drawn from the regression must be taken with a grain of salt. The convergence coefficient was found to be significant at the ninety-nine percent level, yet only one human capital indicator, Life Expectancy, was found to have a significant role in predicting this relationship. All other worker productivity, capital formation, and political inputs were found to be statistically insignificant. Table II does however suggest that an increase in worker health led to an increase in services growth during the sample period. Due to the fact that capital formation is not found to be a significant predictor of cross-country differences in services growth, it is possible that physical capital does not play an important role in determining success in the services sector. The services sector depends more upon human capital, so it makes theoretical sense that physical capital accumulation is found to be insignificant. $Conditional_2$ omits Gross Fixed Capital Formation and an f-test confirms that it is a weak input and should be omitted from the model.

The results of the new regression with Gross Fixed Capital Formation omitted are demonstrated by $Conditional_2$ in Table II. The model is now more robust, with a strong adjusted R^2 and F-statistic. Once again the beta convergence coefficient was found to be both negative and significant, confirming that some convergence occurred across countries from 1980 to 2010. While Secondary School Enrolment remained statistically insignificant, the t-statistic for Life Expectancy increased, suggesting that as a nation's healthcare infrastructure improved, so did long-run services sector growth. Therefore, this study shows that in a cross-section of economies, increases in human capital may have played a role in explaining growth of the services sector. Table II also demonstrates that EXECRLC now is a significant factor input at the ninety percent level. This new result suggests that nations with more left-wing and socially centered political parties experienced faster growth within

the services sector from 1980 to 2010. Similar to Eichengreen and Gupta (2009) and Lee and McKibbin (2014), this study finds that increases in left-wing or democratic institutions led to a faster growth of the services sector as a percentage of GDP.

5.4 Policy Implications

The findings of this study reinforce the case for some policy highlighted by previous economic authors. More specifically, this study finds that similar to Martin and Mitra (1999), Matsuyama (1991), and Lewis (1954), nations with large agriculture sectors may face growth issues in the long-run. However as suggested by Poonyth et. al. (2001), for some nations improving the agricultural sector may be crucial to stimulating industrialization. A major key to accomplishing this goal is promoting the growth of human capital and worker productivity. Table II has demonstrated that over time as nations develop, they tend to move away from agriculture, due to capital deepening, and this will open up labor and capital to migrate to other, more capital-intensive sectors, such as manufacturing and services.

Since research and development for new agricultural technologies is not possible for many individual farmers or manufacturers, investment in new technologies and infrastructure is important to stimulating the structural shift away from agricultural dependence, as highlighted by Guerrieri and Manzocchi (1996) and Broadberry (1993). In addition, improving human capital through increased spending on health and education infrastructure is proven in this study to stimulate agricultural and manufacturing convergence, so developing nations may look into using human capital as a means to improve productivity, especially in the agriculture sector.

Political institutions are also important to agriculture and manufacturing growth, and Table II suggests that more conservative and right-wing governments experienced faster manufacturing growth from 1980 to 2010. Growth literature such as Grossman and Horn (1987) and Baldwin (1969) states that in some cases protecting infant industries and reducing trade liberalization can stimulate domestic manufacturing growth, but this is true only to a certain extent, as in many cases it will decrease social welfare. Too much regulation and protection can lead to difficulty competing in the international market and issues with technology accumulation and corporate corruption. Technology gaps are one of the main reasons behind the difficulty of some nations' manufacturing industries'

ability to catch up to more developed ones, so increasing FDI and trade in manufacturing technology and infrastructure could promote aggregate long-run manufacturing growth.

In recent years the services sector has emerged as a strong source of GDP growth in both developing and developed nations, contrary to Clark (1940) and Chereny (1960). As telecommunications and technology have improved since 1980, so has the prospect of using services growth to create GDP per capita growth, and India has been incredibly successful at this. Table II indicates that there has been convergence within the services sector, so developing nations may want to reallocate some labor and capital to the services sector to aid domestic development. Hoekman and Mattoo (2008) and Lee and McKibbin (2014) have also shown that there are a fair amount of spillover effects from the services sector to other industries through technology accumulation and advancement of sector infrastructure.

6. Concluding Remarks

Using time series data on 56 to 111 economies, this study finds that when conditioned upon human capital, political infrastructure, and a number of sector specific determinants, convergence occurred in agriculture, manufacturing, and services, but absolute convergence occurred only in the manufacturing and services sectors. Further, increases in human capital are found to improve growth in manufacturing and services but exhibit an inverse relationship with growth rate in the agriculture sector. Political infrastructure also exhibits some interesting dynamics within the context of sector specific convergence.

The model indicates that nations are indeed moving towards each other in terms of sectoral value and suggests that as global development occurs, there is a movement away from agriculture as a means to stimulate growth and a transition towards more capital-intensive industries, such as manufacturing and services. In addition, improvement of productivity and political infrastructure is shown to promote manufacturing and services sector growth. There are some issues with the robustness of the results, but the omission of technology accumulation and other heterogeneous domestic factors may be to blame. The key message that emerges from this analysis is that a better understanding of sector productivity and national political infrastructure will enhance the ability of poor countries to catch up to rich ones and should continue to be a topic of further study.

7. References

Alexiadis, S. (2010). Convergence in Agriculture: Evidence from the European Regions. *Agricultural Economics Review*, 11(2), 84.

Baldwin, R. E. (1969). The Case Against Infant-Industry Tariff Protection. *The Journal of Political Economy*, 295-305.

Barro, R. J. (1991). Economic Growth in a Cross Section of Countries. *The Quarterly Journal of Economics,* 106(2), 407.

Barro, R. J., Sala-i-Martin, X., Blanchard, O. J., & Hall, R. E. (1991). Convergence Across States and Regions. *Brookings Papers on Economic Activity*, 107-182.

Bernard, A. B., & Jones, C. I. (1996). Comparing apples to oranges: productivity convergence and measurement across industries and countries.*The American Economic Review*, 1216-1238.

Bernard, A. B., & Jones, C. I. (1996). Technology and convergence. *The Economic Journal*, 1037-1044.

Broadberry, S. N. (1993). Manufacturing and the Convergence Hypothesis: What the Long-Run Data Show. *The Journal of Economic History*, *53*(04), 772-795.

Chenery, H. B. (1960). Patterns of Industrial Growth. *The American Economic Review*, *50*(4), 624-654.

Chenery, H. B., Robinson, S., & Syrquin, M. (1986). *Industrialization and Growth* (p. 45). Washington, DC, USA: World Bank.

Clark, J. M. (1940). Toward a Concept of Workable Competition. *The American Economic Review*, 241-256.

Dasgupta, S., & Singh, A. (2005). Will Services be the New Engine of Indian Economic Growth?. *Development and Change*, *36*(6), 1035-1057.

Dollar, D., & Wolff, E. N. (1993). *Competitiveness, convergence, and international specialization*. Mit Press.

Dollar, D., & Wolff, E. N. (1988). Covergence of Industry Labor Productivity among Advanced Economies, 1963-1982. *The Review of Economics and Statistics*, 549-558.

Dube, L., Pingali, P., & Webb, P. (2012). Paths of Convergence for Agriculture, Health, and Wealth. *Proceedings of the National Academy of Sciences,* 109(31), 12294-12301.

Eichengreen, B., & Gupta, P. (2009). Two Waves of Services Growth. *NBER Working Paper*, *14968*.

Eschenbach, Felix and Bernard Hoekman. 2006b. "Services Policies in Transition Economies: On the EU and WTO as Commitment Mechanisms," *World Trade Review* 5(3), 415-43.

Fisher, A. G. (1939). Production, primary, secondary and tertiary. *Economic Record*, *15*(1), 24-38.

Freeman, D. G., & Yerger, D. B. (2000). Does inflation lower productivity? Time series evidence on the impact of inflation on labor productivity in 12 OECD nations. *Atlantic Economic Journal*, *28*(3), 315-332.

Gollin, D., Parente, S., & Rogerson, R. (2002). The Role of Agriculture in Development. *The American Economic Review*, 92(2), 160-164.

Gootiz, B., & Mattoo, A. (2008). *Restrictions on Services Trade and FDI in Developing Countries*. mimeo (Washington DC: World Bank).

Grossman, G. M., & Horn, H. (1987). Infant-Industry Protection Reconsidered: The Case of Informational Barriers to Entry.

Guerrieri, P., & Manzocchi, S. (1996). *Patterns of Trade and Foreign Direct Investment in European Manufacturing:" Convergence" or" Polarization"?*. (No. 70).

Harrigan, J. (1995). Factor endowments and the international location of production: Econometric evidence for the OECD, 1970–1985. *Journal of International Economics*, *39*(1), 123-141.

Hayami, Y., & Ruttan, V. W. (1985). Population Growth and Agricultural Productivity.

Hoekman, B., & Mattoo, A. (2008). Services Trade and Growth. *World Bank Policy Research Working Paper Series, Vol.*

Hultberg, P. T., Nadiri, M. I., & Sickles, R. C. (2001). Cross-country Catch-up in the Manufacturing Sector: Impacts of Heterogeneity On Convergence and Technology Adoption.

Hultberg, P. T., Nadiri, M. I., & Sickles, R. C. (2004). Cross-country catch-up in the manufacturing sector: Impacts of heterogeneity on convergence and technology adoption. *Empirical Economics*, *29*(4), 753-768.

Jensen, J. B., Kletzer, L. G., Bernstein, J., & Feenstra, R. C. (2005, January). Tradable Services: Understanding the Scope and Impact of Services Offshoring. *In Brookings trade forum* (pp. 75-133). Brookings Institution Press.

Kyriacou, G. (1991). *Level and Growth Effects of Human Capital: A Cross-Country Study of the Convergence Hypothesis*. CV Starr Center for Applied Economics, New York University.

Lucas, R. E. (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics*, 22(1), 3-42.

Poonyth, D., Hassan, R., Kirsten, J. F., & Calcaterra, M. (2001). Is Agricultural Sector Growth a Precondition for Economic Growth? The Case of South Africa. *Agrekon*, 40(2), 269-279.

Poudel, B. N., Paudel, K. P., & Zilberman, D. (2011). Agricultural Productivity Convergence: Myth or Reality?. *Journal of Agricultural and Applied Economics*, 43(01), 143-156.

Martin, W., & Mitra, D. (1999). Productivity Growth and Convergence in Agriculture and Manufacturing.

Mattoo, A., Rathindran, R., & Subramanian, A. (2006). Measuring Services Trade Liberalization and its Impact on Economic Growth: An Illustration. *Journal of Economic Integration*, 64-98.

Matsuyama, K. (1992). Agricultural Productivity, Comparative Advantage, and Economic Growth. *Journal of Economic Theory*, 58(2), 317-334.

Lee, J. W., & McKibbin, W. J. (2014). Service Sector Productivity and Economic Growth in Asia.

Lewis, W. A. (1954). Economic Development with Unlimited Supplies of Labour. *The Manchester School*, 22(2), 139-191.

Rodrik, D. (2012). Unconditional Convergence in Manufacturing*. *The Quarterly Journal of Economics*, qjs047.

Sab, R., & Smith, S. C. (2002). Human capital convergence: A joint estimation approach. *IMF Staff Papers*, 200-211.

Thorsten Beck, George Clarke, Alberto Groff, Philip Keefer, and Patrick Walsh, 2001. "New Tools in Comparative Political Economy: The Database of Political Institutions." 15:1, 165-176 (September), *World Bank Economic Review*.

Wichmann, T. (1996). Technology Adoption in Agriculture and Convergence Across Economies. Retrieved March 02, 2016, from https://www.researchgate.net/publication/4986639_ Technology_Adoption_in_Agriculture_and _Convergence_across_Economies

The World Bank. (2016, February 17). World Development Indicators. Retrieved February 29, 2016, from http://data.worldbank.org/data-catalog/world-development-indicators.