Productivity Growth and Labor Reallocation: Latin America versus East Asia

Murat Üngör†

June 21, 2016

Abstract

Over the period 1963 to 2010, Latin American countries exhibit much slower de-agriculturalization than East Asian countries. The manufacturing employment share has been almost stagnant in Latin America, but exhibits a hump-shaped pattern in Korea and Taiwan. Both groups have moved increasingly toward service-based economies. A nine-sector general equilibrium model, treating sectoral productivity growth rates as exogenous, accounts for some of the differing sectoral allocations of employment in Latin America and East Asia over the sample period. I perform a series of experiments, replacing the sectoral labor productivity growth rates in each sector for each Latin American country with the corresponding growth rates in Korea and Taiwan. Low aggregate productivity growth in Latin America is an economy-wide phenomenon concerning all sectors; however, the findings highlight the possible importance of raising productivity in manufacturing and wholesale to have significant increases in aggregate productivity growth rates. I focus attention on the importance of the level of disaggregation in examining the relationship between labor productivity growth and sectoral movement of labor. Some evidence is presented in linking sectoral policies to productivity growth in Latin America and East Asia.

JEL Classification: C68, O11, O41, O57.
Key Words: East Asia, Latin America, sectoral productivity differences, structural transformation.

*This paper draws on the third chapter of the author’s Ph.D. Dissertation (University of Southern California, 2010). The author is grateful for comments and suggestions from the editor, the associate editor, and the two referees. The author would like to thank Caroline M. Betts, Ayşe İmrohoroğlu, and participants at several seminars and conferences for comments. Part of this research was done while the author was affiliated with the Central Bank of the Republic of Turkey.

†Department of Economics, University of Otago, PO Box 56, Dunedin 9054, New Zealand. E-mail address: murat.ungor@otago.ac.nz
1 Introduction

The development experiences of East Asia (Korea and Taiwan) and Latin America (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, and Venezuela) sharply contrast over the last several decades. Figure 1 shows GDP per person employed (labor productivity) in these two groups relative to the U.S. between 1963 and 2010. East Asia’s productivity level was 15% of the U.S. level in 1963. The catching up of the “Asian Dragons” is visible where labor productivity in East Asia reached to 70% of the U.S. level by 2010. Labor productivity in Latin America increased from 35% of the U.S. level in 1963 to 41.5% in 1980. Latin America experienced a deterioration from 1980 on as the productivity of the group shrank to 25% of the U.S. level in 2010.

There is a sizeable literature attempting to explain (i) the causes of growth in East Asia; (ii) the reasons for Latin America’s failure; and (iii) the poor performance of Latin America relative to East Asia. These comparative studies center on the differences in both policies and institutions in explaining the divergence between the two regions, mostly focusing on the aggregate macroeconomic indicators.

This paper explores the reasons behind this divergence using a multi-sector model of structural transformation. In this transformation, a substantial shift occurs in the composition of employment away from agriculture towards industry and services. For example, the pattern of declining employment share of agriculture, increasing employment share of services, and inverted U-shaped employment share of manufacturing during the last two centuries in the U.S. are well-documented [Acemoglu (2009, Figure 20.1), İşcan (2010, Figure 1)]. Figure 2 displays the evolution of the sectoral employment shares in East Asia and Latin America, in comparison with the U.S., during 1963-2010.

Agriculture accounted for around 48% of employment in 1963 in Latin America, with significant variance across countries (from 22% in Argentina to around 70% in Bolivia). This share declined to 15% in 2010. The decline in the role of agriculture in East Asia is more pronounced (from around 58% in 1963 to less than 7% in 2010). Manufacturing employment share followed a hump-shaped pattern in East Asia. It increased from about 10% in 1963 to about 30% in the late 1980s; it declined since then and was 21% in 2010. The employment share in manufacturing in Latin America has been stagnant, without displaying any significant changes over time, increasing from 14.5% in 1963 to 16% in the late 1980s and declining to 12% by 2010. Mining and utilities jointly account, on average, for less than 2% of employment in each group; and the construction sector makes, on average, up around or less than 6.5% of employment in each group. The U.S. economy, Latin America, and East Asia moved increasingly toward service-based economies, and employment shares in all sub-sectors of services increased both in Latin America and in East Asia.
This paper studies the impact of the sectoral productivity changes on the sectoral reallocation of employment with an emphasis on the differences and similarities between East Asia and Latin America. I contend that the structural change is endogenous to sectoral productivity changes and formulate, accordingly, a nine-sector general equilibrium model that accommodates this. The model abstracts from capital accumulation and international trade and it is effectively a sequence of static resource allocation problems. The reallocation of labor is solely due to the interaction of productivity changes with the type of preferences adopted to focus on the following questions: Can differences in sectoral productivity growth rates account for the sectoral reallocation of labor in Latin America and East Asia? What is the role of productivity growth within individual sectors in Latin America’s falling behind? I present a nine-sector general equilibrium model, characterize the competitive equilibrium, and derive the equilibrium conditions for sectoral employment shares and relative prices. Next, I turn to its quantitative assessment. I explain the calibration of the model parameters and the levels of labor productivity in each sector for each country. Then, I compare the share of employment in each sector for each country in the model and in the data.

I find that the nine-sector model accounts for some of the differing sectoral reallocations of labor in Latin America and East Asia over the sample period, although there are notable differences for some sectors in some countries. I perform a series of experiments, replacing the sectoral labor productivity growth rates in each sector for each country in Latin America with the corresponding growth rates in Korea/Taiwan. The first finding from the experiments is that low aggregate labor productivity growth in Latin America is an economy-wide problem, that is that sectoral productivity growth rates in individual sectors have not been high enough to avoid the stagnation of the overall productivity. The second finding is that the experiments underscore the roles of the manufacturing and wholesale sectors, in comparison with other sectors, in explaining the differences in aggregate productivity growth rates between Latin America and East Asia.

Lastly, I focus attention on particular aspects of the study. The first feature is the importance of the level of disaggregation. A natural question arises is that whether introducing sectoral heterogeneity, i.e., the nine-sector model of this paper’s analysis, into the structural transformation models provide further understanding that three-sector models can fail to deliver or not. I compare the quantitative evaluations of the nine-sector model with those of the three-sector model (agriculture, industry, and services). In addition, I show the importance of the level of disaggregation in a simple decomposition way of the aggregate labor productivity growth. The second aspect is presenting some evidence and anecdotal information concerning the sectoral productivity performances in Latin America and East Asia. The third feature is providing a discussion of the modelling strategy.

The paper proceeds as follows. Section 2 introduces the model. Section 3 explains the calibration procedure, and evaluates the success of the model for each country. Section 4 presents the experiments. Section 5 discusses the possible importance of the disaggregated perspective. Section 6 provides a discussion. Section 7 concludes. Additional figures, tables, and details about the results are in the Online Appendix.\(^8\)

2 A nine-sector model

I write down a nine-sector general equilibrium model in which the sectoral reallocation of employment results both from sectoral differences in productivity growth and from non-homothetic preferences. The sectors are: (1) agriculture (agriculture, hunting, forestry and fishing), (2) mining (mining and quarrying), (3) manufacturing, (4) utilities, (5) construction, (6) wholesale ( wholesale and retail trade, hotels and restaurants), (7) transport (transport, storage and communication), (8) finance (finance, insurance, real estate and business services), and (9) personal services (community, social, personal, and government services). In each sector, productivity grows exogenously and the non-homotheticity in preferences affects the demand for the agricultural good, introducing a subsistence level of consumption in agriculture. Time subscripts are omitted and I focus on the allocation problem solved in a particular period.

Households and preferences. The economy is populated by an infinitely lived representative household of constant size over time. The population size is normalized to one, without loss of generality. I assume that the household is endowed with one unit of productive time, which it supplies inelastically to the market and consumption is the only determinant of the instantaneous utility function, which is given by:

\[ U(\bar{A}, C) = \bar{A} + \log(C). \] (1)

The instantaneous utility is defined over the agricultural good \( \bar{A} \) and the composite consumption good \( C \), which is derived from:

\[ C = \left( \gamma_1^{1/\eta} C_1^{(\eta-1)/\eta} + \gamma_2^{1/\eta} C_2^{(\eta-1)/\eta} + \ldots + \gamma_8^{1/\eta} C_8^{(\eta-1)/\eta}\right)^{\eta/(\eta-1)}, \] (2)

where \( C_1, C_2, \ldots, C_8 \) are the consumption of the non-agricultural goods.9,10 The weights \( \gamma_1, \gamma_2, \ldots, \gamma_8 \) influence how non-agricultural consumption expenditure is allocated among the eight sectors. The parameter \( \eta \) is the (constant) elasticity of substitution among the non-agricultural goods. When \( \eta < 1 \), the non-agricultural goods are complement of each other; and when \( \eta > 1 \), the non-agricultural goods are substitute of each other. At each date, and given prices, the household chooses consumption of each good to maximize its lifetime utility subject to the budget constraint,

\[ p_A \bar{A} + p_1 C_1 + p_2 C_2 + \ldots + p_8 C_8 = \omega, \] (3)

where \( p_j \) is the price of good-\( j \) output and \( \omega \) is the wage rate (normalized to 1).

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9C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8 denote the consumption of mining, manufacturing, utilities, construction, wholesale, transport, finance, personal services, respectively.

10The utility function belongs to the following general type of utility function:

\[ U(A, C) = \begin{cases} \bar{A}, & \text{if } A < \bar{A}, \\ \log(C) + \bar{A}, & \text{if } A \geq \bar{A}. \end{cases} \]

The idea is that consumers care mainly about food up to a satiation point, \( \bar{A} \); beyond that point, their attention focuses on non-agricultural goods (Laitner, 2000; Stokey, 2001; Gollin et al., 2002, 2007).
Firms and technologies. At each date there are nine goods produced. The production function for sector \( j \) is given by
\[
Y_j = \theta_j N_j,
\]
where \( Y_j \) is the output of sector \( j \), \( N_j \) is labor allocated to production, and \( \theta_j \) is sector \( j \)'s labor productivity. Firm \( j \) problem is given by
\[
\max p_j Y_j - \omega N_j \quad \text{s.t.} \quad Y_j = \theta_j N_j, \quad N_j > 0.
\]

Competitive equilibrium. Given a set of prices, \( \{p_A, p_1, p_2, ..., p_8\} \), a competitive equilibrium consists of consumption decisions that are the household’s allocations, \( \{\bar{A}, C_1, C_2, ..., C_8\} \), and factor allocations for the firms, \( \{N_A, N_1, N_2, ..., N_8\} \), such that given prices, the firm’s allocations solve its profit maximization problem, the household’s allocations solve the household’s utility maximization problem, and all product and factor markets clear:
\[
N_A + N_1 + N_2 + ... + N_8 = 1.
\]
\[
\bar{A} = Y_A, \quad C_1 = Y_1, \quad ..., \quad C_8 = Y_8.
\]
The following proposition characterizes the sectoral employment shares at a certain date.

**Proposition 1.** Employment share in agriculture is determined solely by the subsistence term and labor productivity in agriculture:
\[
N_A = \bar{A}/\theta_A.
\]

Employment share in a non-agricultural sector \( j \) is given by:
\[
N_j = \frac{\gamma_j \theta_j^{n-1}(1 - \bar{A}/\theta_A)}{\gamma_1 \theta_1^{n-1} + \gamma_2 \theta_2^{n-1} + \ldots + \gamma_8 \theta_8^{n-1}}, \quad j = 1, 2, ..., 8.
\]

Equation (8) states that employment share in agriculture is negatively correlated with productivity in this sector (and it is independent of productivity in other sectors). Increases in the level of agricultural productivity push labor out of agriculture, since the same amount of agricultural goods can be produced with lower levels of employment. This is consistent with Alvarez-Cuadrado and Poschke (2011) and Üngör (2013).\(^{11}\) Alvarez-Cuadrado and Poschke (2011) study de-agriculturalization in 12 countries since the 19th century, and argue that productivity improvements in the non-agricultural sector were the main driver of the flows of resources out of agriculture before 1960. After that, the evidence indicates productivity changes in agriculture as the driver of change. Üngör (2013) finds that productivity growth in agriculture, combined with the subsistence level of consumption, is able to explain most of the declines in agricultural employment share in several countries during 1963-2005.

Equation (9) provides an explicit characterization of the equilibrium employment share in each non-agricultural sector; and it is obtained combining the first-order conditions for the household maximization problem with the market-clearing conditions. This suggests

\(^{11}\)This formulation excludes the explanation that the improvements in non-agricultural technology attract labor from agriculture (see Lewis, 1954; Harris and Todaro, 1970; Hansen and Prescott, 2002).
that the allocation of labor to a non-agricultural sector depends not only in that sector’s labor productivity but also on productivity in other sectors. A productivity increase in a non-agricultural sector $k$, ceteris paribus, leads to flows of labor out of this sector, i.e., $\partial N_k/\partial \theta_k < 0$ if $\eta < 1$. The model has implication for the relative prices. Because labor is mobile across sectors, there is one wage rate at which the labor market clears. From the profit-maximizing and zero-profit conditions, the producer price of good $i$ relative to good $j$ is given by: $p_i/p_j = \theta_j/\theta_i, i \neq j$.

3 Calibration and model evaluation

3.1 Calibration

The model is parameterized to match the sectoral employment shares in 1963 in the U.S. All time series are de-trended using the Hodrick-Prescott filter with a smoothing parameter of 6.25 before any ratios are computed. I calculate the sectoral productivity levels (value added per worker) from the data (during 1963-2010) and the level of productivity is normalized to 1 for each sector in 1963 in the U.S. There are 10 parameters in the model to assign values to: $\bar{A}, \eta, \gamma_1, \gamma_2, ..., \gamma_8$. I calibrate $\bar{A}$ to match the share of employment in agriculture in 1963 and calibrate $\gamma_j$ to match the share of employment in sector $j$ in 1963. I set $\eta$ to match the average annual growth in aggregate labor productivity in the U.S. during 1963-2010. This suggests that $\eta = 0.4696$. The value of the parameters are reported in Table 1.

I measure the sectoral labor productivity differences across countries at a point in time following Duarte and Restuccia (2010) due to the lack of comparable PPP-adjusted sectoral output data across a large set of countries. Given the value of the parameters, I use the model to solve the levels of labor productivity in each sector for each economy relative to those in the U.S. in 1963. I choose the productivity levels in 1963 to match the sectoral employment shares in each country in 1963 and the aggregate labor productivity relative to that of the U.S. in that year. The levels of sectoral labor productivity implied by the model in 1963 together with data on growth rates of sectoral labor productivity in local currency units suggest time paths for sectoral labor productivity in each country during 1963-2010.

Table 2 displays the levels of labor productivity in each country, relative to the U.S., in 1963. The reported productivity levels are generally reasonable with some exceptions. Restuccia (2012, Table 5), based on Duarte and Restuccia (2010), reports real value added per labor hour in agriculture, industry, and services for Argentina, Bolivia, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela relative to those of the U.S. for 1960 and 2000. Restuccia (2012) reports that Argentina, Chile, and Venezuela were the most productive countries; and Bolivia and Brazil were the least productive countries in agriculture in 1960 among the reported Latin American countries. This finding is consistent with Table 2. Restuccia (2012) states that Venezuela was the most productive country in industry in 1960.

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12 Rogerson (2008), Bah (2010), and Duarte and Restuccia (2010) study three-sector models and calibrate $\eta$ as 0.44, 0.45, and 0.40, respectively, using the U.S. data.

13 I use the Conference Board Total Economy Database (May 2015) to get the aggregate labor productivity figures in 1963. I use the series of GDP per person engaged in 1990 US$ (at Geary-Khamis PPPs).

14 In the Online Appendix, I present a comparison of the obtained productivity levels in this study and those obtained from some (available) sectoral studies.
among all other Latin American countries. In addition, industry’s productivity in Venezuela was higher than that of the U.S. in 1960. I have similar observation for manufacturing in 1963. Restuccia (2012) reports that Venezuela was the most productive Latin American country in the service sector in 1960. Table 2 shows that Venezuela had the highest productivity levels in 1963, in comparison with other Latin American countries, in three sub-sectors of the service sector: wholesale, transport, and personal services. This is no surprise, since GDP per person employed in Venezuela was slightly higher than that of the U.S. in 1963.\footnote{According to the data from the Conference Board Total Economy Database (May 2015), GDP per person employed (in 1990 US$, converted at Geary Khamis PPPs) in Venezuela decreased dramatically relative to that of the U.S. from 100.4\% in 1963 to 36.4\% in 2010.}

Some figures in Table 2 are extraordinarily large, such as eight countries were more productive than the U.S. in finance in 1963. This is due to the fact that employment was so low in these sectors and relative productivity must have been very high to generate the low employment shares. Specifically, the calibration strategy involves matching the sectoral employment shares in each country in 1963 to determine the sectoral productivity levels in that year. In 1963, the employment share of finance, in many countries, was so small, i.e., it was only 0.33\% in Bolivia. On the other hand, the related share was close to 9\% in the U.S. Table 3 reports the average annual growth rates of sectoral labor productivity in each country between 1963 and 2010. Labor productivity growth rates in all sectors in East Asia (except agriculture in Taiwan and finance in Korea) are higher than those of the U.S. A divergence is clearly observed for three big sectors in Latin America: agriculture (save Chile), manufacturing, and the wholesale sector.

### 3.2 Model performance criteria

Figure 3 shows the percentage point change in each sector’s employment share between the first and last years in the model and in the data. The model is particularly successful in replicating the declines in employment share in agriculture in almost all countries, i.e., almost all points are along the 45-degree line. It is worth pointing out the predictive power of the model for Bolivia and Korea, since in 1963 they had higher agricultural employment shares than the other countries studied. In the Bolivian data, the share of employment in agriculture decreases from 69.6\% in 1963 to 19.2\% in 2010. In the model, it decreases to 20.5\% in 2010. For Korea, the model accounts for 95.9\% of the decline in the agricultural employment share during 1963-2010.\footnote{In the model agricultural employment share decreases from 62.3\% in 1963 to 7.6\% in 2010, a \(100\times \ln(62.3/7.6)/47=4.5\%\) annual decrease. In the data it decreases to 7.0\%, a \(100\times \ln(62.3/7.0)/47=4.7\%\) annual decrease. Thus, the model accounts for \(100\times 4.5/4.7=95.9\%\) of the decline in the agricultural employment share in Korea during 1963-2010.} Figure 3 can conceal important country-specific aspects for each sector throughout the years, since there are important differences between the model and the data for some sectors, i.e., some points are above/below the 45-degree line. Table 4 reports four criteria for the performance of the model in replicating the actual sectoral employment shares in each country.\footnote{In the Online Appendix, I present figures that show the model-predicted sectoral employment shares and compare with the data for each country during the entire sample period.}

The first statistic is the root mean square error (RMSE), which is defined as \(RMSE = \)
\sqrt{\frac{\sum_{t=1}^{T}(z_{t}-\hat{z}_{t})^2}{T}}, \text{ where } T \text{ is number of years, } z \text{ is the data value and } \hat{z} \text{ is the model’s predicted value. Lower values of RMSE indicate better fit. Table 4 also reports the sum of the sectoral RMSE values for each country. The second statistic is the modified Nash-Sutcliffe efficiency (NSE) criterion (Nash and Sutcliffe, 1970; Legates and McCabe Jr., 1999). The NSE is defined as } NSE = 1 - \frac{\sum_{t=1}^{T}(z_{t}-\hat{z}_{t})^2}{\sum_{t=1}^{T}(z_{t}-\mu_{z})^2}, \text{ where } \mu_{z} \text{ denotes the sample mean of the data. The closer the model efficiency to 1, the more accurate the model is. A disadvantage of the NSE criterion is that larger values could be strongly overestimated whereas lower values could be neglected, since the differences between the observed and predicted values are calculated as squared values (Legates and McCabe Jr., 1999; Krause et al., 2005). Hence, I use the modified NSE criterion, which is defined as } mNSE = 1 - \frac{\sum_{t=1}^{T}|(z_{t}-\hat{z}_{t})|}{\sum_{t=1}^{T}(|z_{t}-\mu_{z}|+|\hat{z}_{t}-\mu_{z}|)}, \text{ where } |.|. \text{ denotes the absolute value operator. The third statistic is based on the so-called index of agreement (Willmott and Wicks, 1980; Willmott, 1981). The index of agreement, } d, \text{ is defined as } d = 1 - \frac{\sum_{t=1}^{T}(z_{t}-\hat{z}_{t})^2}{\sum_{t=1}^{T}(|z_{t}-\mu_{z}|+|\hat{z}_{t}-\mu_{z}|)^2}. \text{ It varies between 0 and 1, where a value of 1 expresses perfect agreement between the data and the model. In line with the discussion above, I use the following modified index of agreement: } md = 1 - \frac{\sum_{t=1}^{T}|(z_{t}-\hat{z}_{t})|}{\sum_{t=1}^{T}(|z_{t}-\mu_{z}|+|\hat{z}_{t}-\mu_{z}|)}, \text{ which also varies from 0 to 1 with higher values indicating a better fit of the model. These three statistics indicate the degree to which the model predictions deviate from the observed data. The fourth statistic is the correlation statistic (CORR) and measures the degree of association between the model and the data.}

### 3.3 How good is the model?

I compare the total RMSE values to determine in which countries the model fits the data better. The countries are ranked according to their total RMSE values as follows: Argentina, Brazil, Venezuela, Colombia, Bolivia, the U.S., Mexico, Costa Rica, Peru, Chile, Korea, and Taiwan. Argentina has the smallest total RMSE value (0.136) among all the countries in Table 4; and according to this criterion, the model’s explanatory power for structural transformation of the countries is the highest in Argentina. Chile has the highest total RMSE value (0.271) in Latin America. Korea (0.371) and Taiwan (0.408) have higher total RMSE values than those of the Latin American countries. This suggests that the model fits the data of sectoral employment shares better in Latin America than East Asia in overall.

There are six countries in which at least five sectors have mNSE values between 0 and 1: Argentina, Bolivia, Brazil, Chile, Colombia, and Mexico; and there are two countries (Costa Rica and the U.S.) in which four sectors have mNSE values between 0 and 1. At the sector level, the model’s success is greater in agriculture and wholesale. The mNSE lies between 0 and 1 in all countries (save for Peru) in agriculture. In the wholesale sector, the mNSE lies between 0 and 1 in all countries but Taiwan and the U.S. Interpretations of the md generally concur with the mNSE values. Most of the correlations reported in Table 4 are positive and high. The sample correlations between predicted and actual employment shares are more than 0.96 in agriculture (save for Peru). Similarly, the corresponding values are more than 0.95, except for Taiwan and the U.S., in wholesale. There are five countries in which there is one negative correlation between the model and the data: the U.S., Korea, Chile, Costa Rica, and Peru. There are two sectors with negative correlations in Colombia and Mexico.
4 Counterfactuals

4.1 Design of the experiments

For the countries in Latin America, the successes of the model are more, or more important, than its failures. This finding motivates the counterfactuals for this group. Which sector(s) is (are) responsible for the aggregate productivity differences between Latin America and East Asia? I provide several experiments to explore the role of the individual productivity growth rates in understanding the divergence of economic performances between the two regions. The level of the aggregate labor productivity is given by a weighted average of the sectoral productivity levels with the weights being the corresponding employment shares. Sectoral productivity is measured at a common set of prices across countries and I use the prices of the benchmark economy in the initial year. I compute counterfactuals where I set the growth rate of labor productivity in one sector in each Latin American country to the growth rate in that sector in Korea/Taiwan, without changing the other sectoral growth rates. For completeness, I compute a counterfactual where all sectoral growth rates in each Latin American country are set to the corresponding rates in Korea/Taiwan. In sum, the idea is to have the full disaggregation (changing productivity growth rates sector by sector) and the full counterfactual (changing all productivity paths at once).

Panel (a) in Table 5 displays the results of the experiments where I use the sectoral Korean productivity growth rates in each Latin American country. Panel (b) repeats the same experiments using the individual Taiwanese productivity growth rates. The column “Data” shows the actual average annual growth rate of aggregate labor productivity for each country between 1963 and 2010. The column “B” shows the corresponding growth rate using the employment shares of the benchmark solution. The columns “E1”, “E2”, ..., “E10” provide the results of the counterfactuals.\textsuperscript{18} The column “E1” answers the question: What would aggregate productivity growth in Latin America have been if year-by-year labor productivity growth rates in agriculture followed the path observed in Korea/Taiwan during 1963-2010? The column “E2” answers a similar question for mining. The column “E3” (“E4”) shows the results of the experiment for manufacturing (utilities); the column “E5” (“E6”) displays the results for construction (wholesale); the column “E7” (“E8”) reports the results for transport (finance); and the column “E9” exhibits the results for personal services. The column “E10” shows the results of the full counterfactual.

4.2 Results of the experiments

Panel (a) in Table 5 shows that, when comparing the columns “E1”, “E2”, ..., “E9”, the two most important individual sectors are manufacturing (“E3”) and wholesale (“E6”). The impact of feeding the manufacturing productivity growth alone is greater than the impact of the other experiments for each individual sector. For example, the counterfactual for manufacturing in Mexico, Peru, and Venezuela imply growth rates of aggregate labor productivity that are 3.5, 4.6, and 6.0 times higher than the corresponding data, respectively. Similarly, the experiment for manufacturing in Argentina and Colombia in Panel (a) shows that while the counterfactual growth rates of 2.01% and 2.46% are not that impressive overall, for these

\textsuperscript{18}Employment shares are determined endogenously in each counterfactual (see the Online Appendix).
two countries they represent doubling of their aggregate productivity growth rates observed in the data (“E3” vs. “Data”) between 1963 and 2010.

Panel (b) in Table 5 displays that the three most important individual sectors are wholesale (“E6”), personal services (“E9”), and manufacturing (“E3”). The impact of feeding the wholesale productivity growth alone is greater than the impact of the other experiments for each individual sector. For example, the counterfactual for wholesale in Mexico, Peru, and Venezuela imply growth rates of aggregate labor productivity that are 3.6, 5.2, and 6.0 times higher than the corresponding data, respectively, during 1963-2010. The role of the productivity growth in personal services is more pronounced in Panel (b) in Table 5, since Taiwan has shown a significant productivity growth in personal services compared to Korea.

Overall, three important findings emerge. First, all the figures reported in columns “E1” to “E9” in both panels in Table 5 are less than 3%. This suggests that Latin American countries would have not accomplished very high growth rates of aggregate labor productivity by feeding in the individual productivity growth rates (of Korea/Taiwan) alone. Second, although the first finding sounds pessimistic for each individual sector’s contributions to the counterfactual aggregate productivity growth, the results of the experiments for manufacturing and wholesale should not be underestimated. Third, the last experiment, “E10”, points out that if all of the nine sectors had mimicked the productivity growth paths of the Korean (Taiwanese) sectors, then the average annual growth rate of the aggregate labor productivity would have been more than 3% (4%) in Latin America.

I conduct two more experiments to emphasize the role of manufacturing and wholesale in driving the results for the counterfactuals. The column “E11” answers the question: What would aggregate productivity growth in Latin America have been if year-by-year labor productivity growth rates in both manufacturing and wholesale followed the paths observed in Korea/Taiwan during 1963-2010? The column “E12” answers the question: What would aggregate productivity growth in Latin America have been if year-by-year labor productivity growth rates in all other seven sectors (except manufacturing and wholesale) followed the paths observed in Korea/Taiwan during 1963-2010? All the figures reported in the column “E11” are greater than those of the reported ones in the column “E12” in both panels (save for Bolivia and Mexico in Panel (b) in Table 5). For example, if Colombia’s year-by-year labor productivity growth rates in both manufacturing and wholesale followed the paths observed in Korea during 1963-2010 (“E11”), then the resulting aggregate productivity growth in Colombia would have been 94% (=100*3.47/3.69) of the results of the full counterfactual (“E10”). Such an interpretation is strengthened with the ratio of corresponding figure in the column “E12” to the value reported in the column “E10” (39% = 100*1.44/3.69). These experiments show that the impact of feeding the manufacturing and wholesale productivity growth together is very close to the impact of the full counterfactual.19 Changing productivity growth rates of the remaining seven sectors (without changing the productivity growth rates of manufacturing and wholesale) would have not resulted in impressive outcomes.

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19 This finding is in line with McKinsey (2014). McKinsey (2014) centers on the manufacturing, and wholesale and retail services sectors in Mexico and discusses that around 40% of the productivity gap between Mexico and the U.S. is driven by the performance of these two sectors.
5 Importance of disaggregation

There are recent studies that focus on the importance of the sectoral disaggregation on economic development. One of the findings in such studies is that heterogeneity, i.e., sectoral disaggregation, is important within sectors across countries (Herrendorf and Valentinyi, 2012; Eberhardt and Teal, 2013; Duarte and Restuccia, 2015). In their discussion of structural change models, Buera and Kaboski (2009) conjecture that considering higher levels of disaggregation may be a fruitful line of research in developing further understanding of sectoral developments. In the words of Herrendorf et al. (2014, p. 929): “Moving forward, we also think it will be useful to refine the standard three-sector focus of the literature. As today’s advanced economies are increasingly dominated by services, it will be important to distinguish between different activities within services.” Such a point is important, in the scope of this paper, since the share of services (as a whole) in employment increased from 32% in 1963 to 63% in 2010 in Latin America and from 28% in 1963 to around 65% in 2010 in East Asia (see Figure 2).

I provide two quantitative exercises and discuss that the level of disaggregation is important. First, I run the model economy with three-sectors following Duarte and Restuccia (2010) and compare the findings of the three-sector model with those from the nine-sector model. Second, I study a shift-share analysis to decompose aggregate labor productivity growth into different components and show that results are sensitive to the level of disaggregation by performing the same decomposition at two levels of disaggregation.

5.1 Three-sector model versus nine-sector model

From a methodological perspective, the closest paper to this current paper is Duarte and Restuccia (2010). In an influential study, Duarte and Restuccia (2010) study a three-sector (agriculture/industry/services) model and design several experiments to assess the quantitative importance of sectoral labor productivity growth on structural transformation and aggregate productivity. The main methodological difference between this paper and Duarte and Restuccia (2010)(and many other studies in this literature) is that I disaggregate industry and services. I provide a discussion below that such a disaggregation matters.

The quantitative evaluation of the three-sector model is as follows. First, the model is the same as in Section 2. The only difference is that it has three sectors instead of nine. The utility function is now

\[ U(\bar{A}, C) = \bar{A} + \log \left( \gamma_1^{1/\eta} C_I^{(\eta-1)/\eta} + \gamma_S^{1/\eta} C_S^{(\eta-1)/\eta} \right)^{\eta/(\eta-1)}, \]

where \( C_I \) and \( C_S \) denote the consumption of the industrial goods and services, respectively. Second, I use the same (filtered) employment and value-added series for each country with the following adjustment. I construct the time series for industry and services, following Duarte and Restuccia (2010), so that industry includes mining, manufacturing, utilities, and construction; and services includes wholesale, transport, finance, and personal services. Employment and real value added in industry are obtained as a straight sum across mining, manufacturing, utilities, and construction for each country. A similar procedure is followed for the aggregate services. Third, I calculate the sectoral productivity levels from the data and the level of productivity is normalized to 1 for each sector in 1963 in the U.S. There are 4 parameters in the three-sector model to assign values to: \( \bar{A}, \eta, \gamma_I, \gamma_S \). The value of \( \bar{A} \) is
the same as in the quantitative evaluation of the nine-sector model (\( \bar{A} = 0.0501 \)), since there is no change in modelling agriculture. I use the same value for the elasticity of substitution that I use in the nine-sector model (\( \eta = 0.4696 \)). Given the values of \( \bar{A} \) and \( \eta \), \( \gamma_I \) and \( \gamma_S \) are calibrated to match the non-agricultural employment shares in 1963 in the U.S. (\( \gamma_I = 0.3205 \), \( \gamma_S = 0.6795 \)). Fourth, I follow Section 3.1 and solve the initial productivity levels in agriculture, industry, and services in each country.

Table 6 presents the sectoral productivity levels in each sector in 1963. The calibrated productivity levels for agriculture do exactly match the ones reported for the nine-sector model (see Table 2), since modelling agriculture is independent of the number of non-agricultural sectors. There are no extremely big values in Table 6 in comparison with Table 2. This is because of the fact that very small sectors (in terms of employment) in 1963 are now in the composite sectors of industry and services. Table 7 reports the average annual growth rates of labor productivity in agriculture, industry, and services in each country between 1963 and 2010.

I compare the total RMSE values to determine in which countries the model fits the data better in the three-sector model and in the nine-sector model. The countries are ranked according to their total RMSE values in the nine-sector model as follows: Argentina (0.136), Brazil (0.139), Venezuela (0.144), Colombia (0.148), Bolivia (0.159), the U.S. (0.199), Mexico (0.207), Costa Rica (0.222), Peru (0.247), Chile (0.271), Korea (0.371), and Taiwan (0.408). This ranking is changed in the evaluation of the three-sector model and the corresponding ranking in the three-sector model is: Colombia (0.078), Argentina (0.096), Bolivia (0.106), Brazil (0.112), Costa Rica (0.120), Chile (0.132), the U.S. (0.165), Taiwan (0.166), Mexico (0.181), Venezuela (0.206), Peru (0.213), and Korea (0.301). The total RMSE values are lower in the three-sector model (save for Venezuela).

Table 8 reports the counterfactual aggregate productivity growth rates based on the three-sector model. The panel “with Korean Data” displays the results of the experiments where I use the sectoral Korean productivity growth rates in each Latin American country; and the panel “with Taiwanese Data” repeats the same experiments using the individual Taiwanese productivity growth rates. The column “E1” displays the results of the experiment for agriculture. The column “E2” (“E3”) shows the results of the corresponding experiment for industry (services). The column “E4” shows the results of the full counterfactual. The impact of feeding the industry’s productivity growth alone is greater than the impact of the other experiments for each individual sector in the panel “with Korean Data”. On the other hand, the experiment for the aggregate service sector dominates the results of the other two sectors in the panel “with Taiwanese Data”.

I compare the counterfactuals of the three-sector and the nine-sector model. The experiments with Korean rates show that the most important individual sector in the nine-sector analysis is manufacturing and in the three-sector analysis is industry. In industry, manufacturing is the most important sub-sector (in terms of employment) in comparison with mining, utilities, and construction. In that regard, one can argue that there cannot be much to learn from such a disaggregation in industry. However, such a separation is important in the service sector. The experiments with Taiwanese rates show that the most important individual sector in the three-sector analysis is the service sector. In fact, Table 8 shows that Latin American countries would have accomplished higher growth rates of aggregate labor productivity if they had the same year-by-year labor productivity growth rates of Taiwan’s
service sector than they would have accomplished if they had the same year-by-year labor productivity growth rates of Korea’s industrial sector. This finding for Taiwan is consistent with the argument of Duarte and Restuccia (2010, p. 164) that there has been “an increasing role of services in determining cross-country aggregate productivity outcomes.” However, there is more to learn, since the experiments with Taiwanese labor productivity growth data show that the most important individual sector in the nine-sector analysis is wholesale; and the second most important sector is personal services.

Lastly, I state the importance of the level of disaggregation comparing the results of this study with those of Ferreira and da Silva (2015). They study the structural transformation of Latin America with a similar four-sector (agriculture, industry, modern services, and traditional services) model calibrated to the main economies in the region. In Ferreira and da Silva (2015), the modern services comprise transport and finance, while the traditional services group is composed by the wholesale sector and personal services. They find that, in most cases, the poor performance of the traditional services sector is the main cause of the slowdown in productivity growth observed in the region after the mid-1970s and is a key factor in explaining the divergence. The results of Ferreira and da Silva (2015), concerning the importance of the wholesale sector, are consistent with my experiments using data from Korea and Taiwan. Their results regarding the importance of the personal services are consistent with my experiments using data from Taiwan (but not from Korea). Having said that, grouping wholesale and personal services as the traditional services may be subject to the criticism that services rather lack of a definite concept, covering a heterogeneous set of sectors. The wholesale sector is known as one of the market service sectors, while personal services are known as the non-market service sector. The disaggregated perspective of this paper provides additional insights on productivity growth in these sectors.

5.2 A shift-share analysis and disaggregation

de Vries et al. (2012) discuss that the shift-share method is quite sensitive to the level of aggregation (see also van Ark, 1996; Aravena et al., 2014). de Vries et al. (2012) study the role of structural change for growth in Brazil, China, India, and Russia; and compare the results of the shift-share analysis for 3 sectors with those for 35 sectors. For Brazil, during 1995-2008, they find a large contribution from employment reallocation to services (0.6% points), explaining about half of aggregate growth. However, the reallocation term drops to 0.1% points when decomposing growth at the 35-sector level rather than the 3-sector level. de Vries et al. (2012) state that within the services sector labor moves to sub-sectors such as retail trade and renting of machinery and equipment and other business activities which have below average productivity levels. Hence the reallocation effect becomes much smaller in the analysis of detailed sub-sectors. This provides motivation for the following exercise. I express the labor productivity for the economy as a whole as the productivity level by sector weighted by the sectoral employment shares. Then, I decompose labor productivity growth into various components as follows:

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Market services include wholesale and retail trade, restaurants and hotels; transportation, communication and storage; finance, insurance, real estate and business services; and non-market services include community, social and personal services (see Timmer and de Vries, 2009).
The left-hand side of Equation (10) is the overall labor productivity growth between years 0 and $T$, $j$ is the sector, $\alpha_{jT}$ is the share of employment in sector $j$ in year $T$, and $\theta_{jT}$ is the labor productivity in sector $j$ in year $T$. The intra-sectoral effect (or within-effect) shows the part of the overall productivity change caused by productivity growth within the sectors. The structural-change effect (or reallocation-effect) captures the effect on aggregate labor productivity growth from changes in the sectoral structure of the economy. It has two components. The static effect gives the contribution arising from changes in the sectoral composition of employment and the dynamic effect represents the joint effect of changes in employment shares and sectoral productivity.

Table 9 shows the percentage contributions of the three sources of the aggregate labor productivity growth for each country during 1963-2010. The three effects are measured at two levels of disaggregation. In most of the cases, the three-sector disaggregation gives a somewhat bigger weight to the structural-change effect (sum of the static and dynamic terms), whereas the nine-sector disaggregation leaves more of the explanation to intra-sectoral effect. The sign of the structural-change effect changes depending on the level of disaggregation in Bolivia and Taiwan. Using the three-sector disaggregation, the reallocation-effect accounts for $61\% \ (=100\% (1.17+(-0.93))/0.40)$ of the aggregate labor productivity growth in Bolivia between 1963 and 2010. On the other hand, the reallocation-effect is negative in the nine-sector disaggregation for Bolivia due to the dominant negative joint-effects. The main source of this negativity is the finance sector, i.e., finance constitutes $45\%$ of the negative dynamic-effect in the nine-sector disaggregation in Bolivia. Employment share of finance in Bolivia experienced a more than twenty-fold increase between 1963 and 2010, whereas the productivity level of this sector in 2010 was around $12\%$ of the 1963 level.

The dynamic effect has negative contributions to aggregate labor productivity growth in East Asia in the nine-sector disaggregation, whereas positive contributions of the joint effects are found in the three-sector disaggregation. In Taiwan, the dynamic-effect is negative using the nine-sector disaggregation and the source of the sign is the mining sector. Employment share of mining in Taiwan in 2010 was almost zero ($=0.04$) and the very low levels of employment relative to the value added figures result in big productivity values. This results in a significant negative dynamic-term for the mining sector and this dominates the outcome in the nine-sector disaggregation. This effect vanishes when mining is a part of the industry in the three-sector aggregation. In Korea, positive joint effects contributions of industry and services outweigh the negative dynamic terms of agriculture in the three-sector disaggregation. However, in the nine-sector disaggregation, negative contributions of agriculture, mining and finance to the dynamic effects dominate the positive contributions of other six sectors. The three-sector framework shadows such negative effects.


6 Discussion

6.1 Some evidence and anecdotal information

The results of the counterfactual experiments motivate the following questions that Herrendorf et al. (2014, p. 928) ask for the factors that influence sectoral productivity growth rates in general: “But if the paths of productivity differ significantly across countries, then it is important to ask what factors are responsible for these differences? If the differences are more pronounced in particular sectors in particular countries, what are the factors that account for this? Is it policies that influence the diffusion of technology, or perhaps policies that generate misallocation of inputs across producers?”

In the context of this current paper, main findings from the counterfactuals stimulate the question, Why have been sectoral productivity growth rates been poor in Latin America in comparison with Korea and Taiwan? The experiments can provide guidance on what needs to change to improve sectoral productivity growth rates in Latin America. In other words, for the counterfactuals to be economically meaningful, a feeling needs to be acknowledged that some changes would have allowed the countries in Latin America to have productivity growth that had matched East Asia. With this thought in mind, I provide a discussion of sectoral distortions and policies that possibly have affected sectoral productivity growth in Latin America.

6.1.1 Economy-wide distortions

One of the findings from the experiments is that sectoral productivity growth rates in individual sectors have not been high enough to avoid the stagnation of the overall productivity. In other words, low aggregate labor productivity growth in Latin America is an economy-wide problem. Many studies present evidence in recording the sectoral distortions in Latin America that have suppressed sectoral productivity growth rates. Different studies emphasize different type of distortions regarding the non-agricultural policies in Latin America that hinder productivity growth, such as restrictive labor laws concerning retaining policies, high taxation, legal requirements and completion times for business processes, price, product, and service regulations, and government ownership.

Elstrodt et al. (1994) focus on Argentina, Brazil, Colombia, Mexico, and Venezuela and conduct industry-specific case studies in steel, food processing, telecommunications, and retail banking sectors. They argue that in almost all of these Latin American countries, protectionism and regulation have prevented competition. Cole et al. (2005) document Latin America’s high protectionism, high costs to starting a new business, government ownership of banks, and stifling labor market regulations at the sector level. McKinsey (2006) discusses that two-thirds of the difference in productivity between Brazil and the U.S. are due to the five primary barriers in Brazil: the large informal sector, macroeconomic factors hampering investment, regulatory constraints, inefficient public services, and the country’s infrastructure. Kehoe and Ruhl (2010) argue that Mexico needs reforms that eliminate barriers to

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21In the Online Appendix, I provide some evidence regarding the distortions in agriculture in Latin America (especially in the 1960-1980 period) that, possibly, played a role in suppressing agricultural productivity growth, and hence causing a slower pace of de-agriculturalization in Latin America.
growth of an inefficient financial system, lack of rule of law, and rigidities in the labor mar-
ket. Restuccia (2012) argues that barriers to formal market entry, regulation and barriers
to competition, trade barriers and employment protection are important to understand the
productivity differences between Latin America and the U.S.

Informality, i.e., the failure of business activities to meet key legal and tax requirements,
is a general problem in Latin America (World Bank, 2007) and it can be seen as both a
symptom and a cause of low productivity growth rates in some sectors such as construc-
tion, manufacturing, and retailing (Marcouiller et al., 1997). Leal Ordóñez (2014) studies a
calibrated model using data for Mexico and lists three distortions induced by the informal
sector: (i) a misallocation of resources towards small and unproductive plants, as they en-
gage in tax evasion; (ii) a distortion in occupational choices as unproductive entrepreneurs
are attracted to the market; (iii) a distortion in the capital use of informal establishments, as
they reduce their scale to remain undetected. Informality distorts factor costs reducing the
incentives to invest in productivity improvements. For example, Busso et al. (2012), using
economic census data for manufacturing, retail and wholesale, and services, find evidence
for the view that the distortions caused by informality do lower productivity in Mexico.
Baily et al. (1998) state that with its high degree of informality and outmoded production
processes, residential construction has the lowest productivity in the overall construction sec-
tor in Brazil. McKinsey (2006) notes that the percentage of those working in the informal
economy increased from 66% in 1996 to 72% in 2003 in Brazil’s construction sector.

Two parallel studies by the McKinsey Global Institute (McKinsey, 1998a; 1998b) present
productivity comparisons between Brazil and Korea in several goods-producing industries
(automotive, food processing, and steel) and in service sectors (airlines, retail banking, tele-
com). Several reasons are emphasized in these two studies for the observed productivity
differences in Brazil and Korea. One set of reason includes the operational causes such as
differences in manufacturing processes, capacity utilization, levels of automation, etc. For
example, in steel, Korea’s higher labor productivity compared to Brazil was driven by tech-
nology differences. In 1995, Brazil’s steel mills were significantly less automated than those
of Korea, and only 68% of Brazil’s production facilities utilized continuous casting, compared
to 98% for Korea (McKinsey, 1998b). Another reason is differences in sectoral concentration
practices. Several examples are presented to show that Brazilian competition policy has been
characterized by high levels of concentration and low competitive intensity. For example,
in 1996, Brazilian retail banking sector included both public and private banks, with public
banks holding 60% of deposits, whereas Korea had only 12% of deposits in public banks. The
Brazilian sector had a high-level of concentration, with the six largest banks holding 70%
of deposits in 1996, whereas Korea and the U.S. had extremely low levels of concentration.
Barriers to entry and fostering competition among existing players, and sectoral regulation
problems are also listed as sources. In steel, 70-100% of the market for most products was
held by one or two producers in Brazil (McKinsey, 1998a). Domestic airfares in 1995 in
Brazil were very high compared to international standards in less regulated markets; and
regulation of domestic travel led to costs of a flight from Sao Paulo to Rio de Janeiro of
roughly $300 compared to $80 for a similar length flight in Korea (McKinsey, 1998a).
6.1.2 Manufacturing and wholesale

The second finding comes out of the experiments is that the possible importance of raising productivity in *manufacturing* and *wholesale* (wholesale and retail trade, hotels and restaurants) to have significant increases in aggregate productivity growth rates. The food processing sector in Brazil, one of the largest manufacturing sector in the country, is an illustrative case example of the relationship between distortions and productivity as described in Baily et al. (1998, p. 86): “In the milk industry, for example, controls on raw milk prices resulted in an uncompetitive sector full of small, informal, and unproductive operators. The scale of inefficiency is such that one processing plant in the north-east of Brazil relies for its supplies on producers whose output is less than two liters a day.” Machicado and Birbuet (2012) study productivity dispersion in the Bolivian manufacturing sector during 1988-2001; and find that if resource misallocation was eliminated, the gains in productivity would have been on the order of 54%.

Table 3 shows that all of the Latin American countries (save Chile) have negative average annual growth rates of labor productivity in the wholesale sector during 1963-2010. In contrast, this sector has been the most productive service sector in Taiwan and the second most productive service sector in Korea (after the transport sector). The Latin American retail sector comprises public and itinerant markets, street vendors, mom-and-pop and corner stores, and specialized retailers as well as large self-service and convenience store chains. A large number of small, informal markets compete directly with larger, formal supermarkets. There was period of sustained growth of the so-called modern retail sector in Latin America in the 1990s. The globalization of retailing has resulted in rapid proliferation of supermarkets throughout Latin America, where multinational retailers led investment in the 1990s and supermarkets increased their market shares in Latin America. As a result, thousands of traditional small shops and mom-and-pop and corner stores went out of business.

Lagakos (2016) finds that value added per worker is much higher in the modern segment than in the traditional segment of the retail sector in Argentina, Brazil, and Mexico. However, small retailers still endure in Latin America thanks to different factors, such as informality, informal credit (the operator writes the name of the debtor in a small notebook), virtual wallet (when the customer is short of small amounts of cash at the register and is allowed to pay the next time), etc. (see D’Andrea et al., 2006). To the degree the wholesale sector is discussed, one interpretation could be that the scales in the retail sector may be optimal given the level of development. Lagakos (2016) provides an alternative explanation in

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22 The transport sector has a higher rate of average annual productivity growth than the other components of services in most of the Latin American countries (except Colombia, Peru, and Venezuela). Echevarria (1997, Table 4) has similar observation for many OECD countries that the transport sector has a higher rate of technical change in comparison with the other sub-sectors of services.

23 Walmart’s first store outside the U.S. opened in Mexico in 1991 and Wal-Mart opened stores in Argentina and Brazil in 1995. It is reported in Rodríguez et al. (2002) that in 1984, in Argentina, supermarkets had 27%, modern self-service (convenience) stores 17%, and traditional shops 56% of food retailing. By 1990, the shares were 34%, 21%, and 44%, respectively; and by 1999 supermarkets had 58%, while traditional stores had only 19%. Faiguenbaum et al. (2002) report that supermarkets spread rapidly during the 1990s in Chile, reaching 62% of total food retailing in 2001.

his study of the productivity differences in retail trade and argues that low measured productivity in developing-country retail largely represents optimal choice of technology adoption given these countries’ low income level.

Another interpretation is that Latin America is more distorted than East Asia and the absence of productive reallocation has been suppressing the productivity growth in this sector (de Vries, 2014.) My observations (Table 3) and findings from the experiments (Table 5) suggest that the rapid modernization of the wholesale sector did not provide significant productivity increases for the overall sector. This stream of thought is in line with the view that Latin America is more distorted than East Asia and the absence of productive reallocation has been suppressing the productivity growth in this sector. For example, de Vries (2014) studies allocative efficiency in the retail sector of Brazil, and measures distortions in the retail sector by comparing marginal revenue products with the costs of factor inputs. de Vries (2014) uses census data for Brazil’s retail sector and argues that improvements in resource reallocation may improve productivity levels by a factor of two, which would bring productivity levels in Brazil’s retail sector between 28 and 56% of the U.S. productivity level.

6.2 On modelling and relations to the literature

In my model, structural change occurs due to the two channels. The first channel is non-homothetic preferences due to the subsistence level of consumption in agriculture (Kongsamut et al., 2001). The second channel is differences across sectors in productivity growth (Ngai and Pissarides, 2007). The model ignores (possible) differences in capital intensities across sectors. Acemoglu and Guerrieri (2008) study a model in which capital deepening tends to increase the relative output of the more capital-intensive sector but simultaneously induces a reallocation of capital and labor away from that sector (depending on the elasticity of substitution between sectors). Regarding the absence of the capital, a practical motivation is the difficulty associated with the available sectoral capital stock data dating back to the 1960s. In addition, having capital in the model may not matter a lot for the structural change. Dennis and İşcan (2009) argue that even if sectors have different rates of capital deepening, this effect may not have a large impact on the rate of labor reallocation across sectors. Dennis and İşcan (2009) study a two-sector model for the U.S. (agriculture and non-agriculture) to illustrate the potential relevance of the three channels of the structural change mentioned above. They find that differential capital deepening is the least important factor contributing to the structural change during 1950-2000 (see also İşcan, 2015). Similarly, Acemoglu and Guerrieri (2008) state that their main contribution is theoretical and their calibration exercises indicate that the proposed mechanism can generate changes in relative employment levels that are in the same direction as in the data, though quantitatively smaller in the postwar U.S. data.

The model economy also ignores the effect of openness that can explain some of the failures of the model economy, especially in East Asia. For example, my model generates the hump-shaped pattern of the manufacturing employment share, and correctly predicts the peak date, which is 1989, for manufacturing employment share, in Korea during 1963-2010. Although creating the inverted U-shaped employment share of manufacturing, my model under-predicts the employment share of this sector by 50% between 1964 and 2010.
in Korea. Betts et al. (2013) and Uy et al. (2013) discuss that openness is quantitatively important for explaining Korea’s structural change. Uy et al. (2013) note that while their open-economy model can quantitatively explain the rising portion of Korea’s hump-shape in manufacturing, it does not explain the declining portion of the hump. Uy et al. (2013) argue that the key missing country from the calibrated model is China, and suggest that including China as a third country would help explain the declining portion of Korea’s hump. In addition, the openness channel may provide some insights for the observed labor productivity growth differences. Connolly and Yi (2015) study the importance of trade reforms in explaining Korea’s growth in output per worker and trade during 1962-1989 and find that the broad Korea tariff reduction can explain up to 17% of Korea’s catch-up to the G7 countries in value-added per worker in the manufacturing sector.

Lastly, this paper is related to a number of literatures. First, this paper complements the studies on convergence at the sectoral level, which assess the importance of the different sectors. Second, this paper is related to the literature, which analyzes the sources of the structural transformation; and examines the interrelationship between the changes in sectoral composition and the changes in aggregate productivity. Third, this paper goes beyond the studies on the structural change that use shift-share analysis. Those studies look at the contributions of structural change and sectoral productivity growth to aggregate labor productivity growth (Timmer and de Vries, 2009; McMillan and Rodrik, 2011). While such studies reveal information about the lack of convergence between countries, they do not provide an understanding of how employment shares would have changed under alternative scenarios and how the combined changes of productivity and employment shares affect aggregate productivity. I present such experiments based on a model.

7 Concluding remarks

In the early 1960s, many Latin American countries had far higher standard of living than South Korea and Taiwan. Since then, these two countries have showed spectacular growth performances and by the 1980s Korea and Taiwan had overtaken even the more developed countries of Latin America such as Argentina and Chile. In 1963, Korea’s GDP per person employed was around one-third of Argentina’s, while in 2010 it was almost two times that of Argentina’s. Why is it that Latin America remains underdeveloped, while Korea and Taiwan that were poor 4-5 decades ago have managed to develop? This study explores this question in a sectoral perspective. I provide an analysis of structural change in Latin America and East Asia concerning with the differential development of the nine sectors. Instead of studying a two-sector (agriculture/non-agriculture) or a three-sector (agriculture/industry/services) model, studying a nine-sector model allows for possible sectoral heterogeneity in industry

\[\text{The related figures in the Online Appendix show that the employment share in manufacturing increased from 7.9\% in 1963 to 27.6\% in 1989. Since then, Korea has been in a process of de-industrialization and the employment share in manufacturing decreased to 17.8\% in 2010. The model produces this hump-shaped pattern: an increase from 7.9\% in 1963 to 10.8\% in 1989; and then decrease to 6.7\% in 2010.}\]

\[\text{See Bernard and Jones, 1996a,b; Sørensen, 2001; Inklaar and Timmer, 2009; van Biesbroeck, 2009; Castellacci et al., 2014 for detailed discussions.}\]

and in services. An evaluation of the model for each country reveals that the nine-sector model, treating sectoral productivity growth rates as exogenous, has some explanatory power in accounting for the structural transformation experiences of most of the Latin American countries. Productivity growth in Latin America in each sector, with a few exceptions, lagged behind that of Korea and Taiwan during 1963-2010. The findings highlight the possible importance of raising productivity in manufacturing and wholesale to have significant increases in aggregate productivity growth rates in Latin America. I present some information on policies that affect sectoral productivity growth in Latin America and East Asia.

Appendix A

Sectoral data are from the Groningen Growth and Development Centre (GGDC) 10-sector database, version 2014 (http://www.rug.nl/ggdc/productivity/10-sector). The database includes annual data on gross value added at current, and constant prices from 1950 onwards. In addition, annual data on persons employed is available, which allows the derivation of labor productivity (value added per worker). Data on the number of workers is based on the broadest employment concept, including self-employed, family-workers and other informal workers (Timmer et al., 2014). Data for Korea and Taiwan (employment by sector) start from 1963. Therefore, I study the 1963-2010 period. The database covers the ten main sectors: (1) agriculture, hunting, forestry and fishing, (2) mining and quarrying, (3) manufacturing, (4) utilities (electricity, gas and water supply), (5) construction, (6) wholesale and retail trade, hotels and restaurants (7) transport, storage and communication, (8) finance, insurance, real estate and business services, (9) community, social and personal services, and (10) government services. Together these ten sectors cover the total economy. For some countries, this database only provides value added or employment for the sum of “community, social and personal services” and “government services,” rather than their breakdown. I aggregate their real value added and employment and consider them as a single sector. Thus, I use nine sectors.

References


Connolly, M., Yi, K.-M. 2015. How much of South Korea’s growth miracle can be explained by trade policy? American Economic Journal: Macroeconomics, 7, 188-221.


Table 1: Calibration of the parameters

\[ A = 0.0501; \gamma_1 = 0.0095; \gamma_2 = 0.2451; \gamma_3 = 0.0074; \gamma_4 = 0.0585; \gamma_5 = 0.2156; \gamma_6 = 0.0652; \gamma_7 = 0.0900; \gamma_8 = 0.3087; \eta = 0.4696 \]

Table 2: Calibrated sectoral productivity levels in 1963

<table>
<thead>
<tr>
<th>Country</th>
<th>Agriculture</th>
<th>Mining</th>
<th>Manufacturing</th>
<th>Utilities</th>
<th>Construction</th>
<th>Wholesale</th>
<th>Transport</th>
<th>Finance</th>
<th>Personal</th>
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<tbody>
<tr>
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Table 3: Average annual growth of labor productivity by sector (%), 1963-2010

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RMSE: Root mean square error; mNSE: Modified Nash-Sutcliffe efficiency; md: Modified index of agreement; CORR: Correlation.
Table 5: Average annual growth of aggregate labor productivity (%), 1963-2010

(a): Using productivity of Korea

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(data): Data; B: Benchmark; E1: Experiment for agriculture; E2: Experiment for mining; E3: Experiment for manufacturing; E4: Experiment for utilities; E5: Experiment for construction; E6: Experiment for wholesale; E7: Experiment for transport; E8: Experiment for finance; E9: Experiment for personal services; E10: Experiment for all sectors; E11: Experiment for manufacturing and wholesale; E12: Experiment for all sectors (excluding manufacturing and wholesale).

(b): Using productivity of Taiwan

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Table 6: Productivity levels in 1963

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Table 7: Productivity growth (%), 1963-2010

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<th>Services</th>
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</tr>
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<td>1.23</td>
<td>-0.10</td>
</tr>
<tr>
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<td>0.89</td>
</tr>
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Table 8: Average annual growth of aggregate labor productivity (%), 1963-2010

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<th>E2</th>
<th>E3</th>
<th>E4</th>
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D: Data; B: Benchmark; E1: Experiment for agriculture; E2: Experiment for industry; E3: Experiment for services; E4: Experiment for all sectors.

Table 9: Relative contribution of different sources (%), 1963-2010

<table>
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<tr>
<th>Country</th>
<th>Overall productivity change</th>
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<th>3-sector disaggregation</th>
<th>3-sector disaggregation</th>
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<td>Intra Static Dynamic</td>
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</tr>
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<td>1.00 0.08 -0.44</td>
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<tr>
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<tr>
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<td>0.44 0.57 -0.40</td>
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<td>0.62 0.22 -0.23</td>
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</tbody>
</table>

Note: This analysis is based on the original (unfiltered) series. Data are from the Groningen Growth and Development Centre (GGDC) 10-sector database, version 2014.
Figure 1: Labor productivity relative to the U.S. (%), 1963-2010

Figure 2: Sectoral employment shares (%), 1963-2010

(Black: East Asia; Blue: Latin America; Red: U.S.)
Figure 3: Percentage point change in the sectoral employment shares, 1963-2010

KOR: Korea; TWN: Taiwan; ARG: Argentina; BOL: Bolivia; BRA: Brazil; CHL: Chile; COL: Colombia; CRI: Costa Rica; MEX: Mexico; PER: Peru; VEN: Venezuela; USA: United States.