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The Role of the Structural Transformation in Aggregate Productivity

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Abstract

We investigate the role of sectoral differences in labor productivity and the process of structural transformation (the secular reallocation of labor across sectors) in accounting for the time path of aggregate productivity across countries. Using a simple model of the structural transformation that is calibrated to the growth experience of the United States, we measure sectoral labor productivity differences across countries. These differences are large and systematic: labor productivity differences between rich and poor countries are large in agriculture and services and smaller in manufacturing. When fed into the model, these sectoral labor productivity differences and the structural transformation they produce account for more than 50 percent of the fast catch-up in aggregate productivity observed in less developed economies and all of the stagnation and decline observed in more developed economies in recent decades.

Keywords: labor productivity, structural transformation, sectoral productivity, employment, hours, cross-country data.
JEL Classification: O1,O4.

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1 Introduction

It is a well-known observation that over the last 50 years countries have experienced remarkably different paths of economic performance.[1] Looking at the behavior of GDP per hour of individual countries relative to that of the United States we find experiences of sustained catch-up, catch-up followed by a slow-down, stagnation, and even decline (see Figure 1 for some illustrative examples).[2] Consider for instance the experience of Japan. Between 1960 and 2000, GDP per hour in Japan relative to that of the United States rose from about 20 percent to about 60 percent.[3] Spain also experienced a period of rapid catch-up to the United States from 1960 to the mid 70s, a period during which relative GDP per hour rose from about 40 to 65 percent. In the mid 70s, however, this process slowed-down dramatically and relative GDP per hour in Spain stagnated until 2000. Another remarkable growth experience is that of New Zealand where in 1970 GDP per hour was close to that of the United States but by 2000 it had fallen to less than 70 percent.

Along their modern path of development countries undergo a process of structural transformation by which labor is reallocated among agriculture, industry, and services. Over the last 50 years many countries have experienced substantial amounts of labor reallocation across sectors. For instance, from 1960 to 2000, the share of employment in agriculture in Spain fell from 42 to 7 percent while the share of employment in services rose from 26 to 63 percent. In about the same period, the labor share in agriculture in Belgium fell just from 9 to 2 percent, while the labor share in services rose from 43 to 75 percent.

In this paper we study the behavior of GDP per hour over time from the perspective of sectoral productivity growth and the structural transformation.[4] Is the reallocation of labor across sectors important in understanding the behavior of aggregate productivity? At a qualitative level, the answer to this question is clearly yes. Since aggregate labor

[1] See, for instance, Chari, Kehoe, and McGrattan (1996), Jones (1997), Prescott (2002), Duarte and Restuccia (2006), among many others.

[2] We use GDP per hour as our measure of economic performance. Throughout the paper we refer to labor productivity, output per hour, and GDP per hour interchangeably.

[3] All numbers reported refer to trend data using the Hodrick-Prescott filter. See Section 2 for details.

[4] See Baumol (1967) for a discussion of the implications of structural change on aggregate productivity growth.

productivity can be expressed as the sum of labor productivity across sectors weighted by the share of labor in each sector, the structural transformation may matter for aggregate productivity. At a quantitative level the answer depends on whether there are substantial differences in sectoral labor productivity across countries. Our approach in this paper is to first develop a simple model of the structural transformation that is calibrated to the growth experience of the United States. We then use the model to measure sectoral labor productivity differences across countries. These measures, together with data on sectoral labor productivity growth, imply time paths of sectoral labor productivity across countries. We use these measures of sectoral labor productivity in the model to assess their quantitative role on aggregate productivity outcomes across countries.

We find that there are large and systematic differences in sectoral labor productivity across countries. In particular, labor productivity differences between rich and poor countries are larger in agriculture and services but smaller in manufacturing. To illustrate the implications of these differences for aggregate productivity, imagine that these productivity differences remain constant as countries undergo the structural transformation. Then as developing countries reallocate labor from agriculture to manufacturing, aggregate productivity can catch-up as labor is reallocated from a low relative productivity sector to a high relative productivity sector. Instead, countries further along the structural transformation can stagnate or decline as labor is reallocated from manufacturing (a high relative productivity sector) to services (a low relative productivity sector). When sectoral labor productivity is fed into the model of the structural transformation, we find that low productivity growth in services accounts for all of the decline, stagnation, and slow-down in relative aggregate productivity observed in more developed economies such as Canada and New Zealand. Moreover, productivity growth in industry accounts for more than 50 percent of the catch-up in relative aggregate productivity observed in the 60s in many of the less developed economies such as Spain and Austria.

We construct a panel data set on output per hour from the Penn World Table version 6.1 (PWT6.1) and the Total Economy Database, and disaggregated output and employment observations for agriculture, industry, and services from a variety of sources (see the Appendix for a detailed explanation). Our panel data includes 29 countries with data covering the period from 1956 to 2000 for most countries.[5] From these data, we document three basic facts. First, countries follow a common process of structural transformation characterized by a declining share of employment in agriculture over time, an increasing share of employment in services, and a hump-shaped share of employment in industry. Second, there is substantial lag in the process of structural transformation for some countries and this lag is associated with the level of relative income. Third, there are sizable and systematic differences in sectoral growth rates of labor productivity across countries. In particular, whereas countries with high annualized growth rates of aggregate productivity observe high growth rates of labor productivity in agriculture and specially manufacturing, that is not the case for services. To put it differently, we find that a large number of countries catching up in aggregate productivity to the level of the United States are not catching up in labor productivity in services. This finding partly explains the role of services in accounting for growth experiences of stagnation and decline for the more advanced countries. Countries with low annualized growth rates of aggregate labor productivity tend to observe low labor productivity growth in all sectors.

We develop a simple general equilibrium model of the structural transformation with three sectors – agriculture, industry, and services. Following Rogerson (2007), labor reallocation across sectors is driven by two channels: income effects due to non-homothetic preferences and substitution effects due to differential productivity growth across sectors.[6] We calibrate the model to the structural transformation of the United States between 1956 and 2000. A model of the structural transformation is essential for the purpose of this paper for two reasons. First, we need the model to measure sectoral productivity differences across countries. While there are many studies quantifying cross-country labor productivity differences in some sectors (most notably the efforts of the Food and Agricultural Organization, FAO, the Organization for Economic Co-operation and Development, OECD, and

[5] Our sample does not include the poorest countries in the world: the relative labor productivity difference between the richest and poorest countries in our data is a factor of only 10.

[6] For recent models of the structural transformation emphasizing non-homothetic preferences see Kongsamut, Rebelo, and Xie (2001) and emphasizing substitution effects see Ngai and Pissarides (2007).

the McKinsey Global Institute, MGI), these studies do not provide enough information for a systematic cross-country aggregate analysis over time. Moreover, these studies are typically done for narrowly defined sectors. One reason for this lack of information is that the data requirements for internationally comparable measures of sectoral output over time are enormous. Nevertheless, in Section 4 we argue that our measured sectoral productivity differences are broadly consistent with the sparse micro evidence available. Second, the process of structural transformation is endogenous to the level and changes over time in sectoral labor productivity. As a result, a quantitative assessment of the aggregate implications of the structural transformation and sectoral productivity differences requires the changes in the distribution of labor across sectors to be consistent with sectoral productivity.

This paper is related to a large literature studying income differences across countries. Within this literature, our paper is connected to the literature studying international income differences in the context of models with delay in the start of modern growth.[7] Since countries in our data set have started the process of structural transformation well before the first year in our sample, our focus is on measuring sectoral productivity across countries at a point in time and on assessing the role of their movement over time in accounting for the patterns of structural transformation and aggregate productivity experiences across countries.[8] In studying labor productivity over time, our paper is also related to a recent literature that studies country episodes of slowdown and depression.[9] Most of this literature focuses on the role of exogenous movements in aggregate total factor productivity and aggregate distortions on GDP per worker relative to trend. We differ from this literature by emphasizing the importance of the structural transformation and sectoral labor productivity on the secular movements in relative GDP per hour across countries.

The paper is organized as follows. In the next section we document some facts about the process of structural transformation and sectoral labor productivity growth across countries.

[7]See, for instance, Lucas (2000), Hansen and Prescott (2002), Ngai (2004), and Gollin, Parente, and Rogerson (2002).

[8]Herrendorf and Valentinyi (2006) also use a model to measure sectoral productivity differences across countries. They use aggregate expenditure data in a model with four sectors.

[9]See Kehoe and Prescott (2002) and the references therein. See also Coleman (2007) and Adamopoulos and Akyol (2007).

Section 3 describes the economic environment and calibrates a benchmark economy to U.S. data for the period between 1956 to 2000. In section 4 we discuss our quantitative experiment and perform counterfactual analysis. We conclude in section 5.

2 Some Facts

In this section, we document the process of structural transformation and the behavior of labor productivity in agriculture, industry, and services for the countries in our data set at an annual frequency. Since we focus on long-run trends, data are trended using the Hodrick-Prescott filter with a smoothing parameter $\lambda = 100$. For a detailed description of the data, sample of countries, and time coverage for each country see the appendix.

2.1 The Process of Structural Transformation

The reallocation of labor across sectors over time is typically referred to in the economic development literature as the process of structural transformation. This process has been extensively documented.[10] The structural transformation is characterized by a systematic fall in the share of employment in agriculture over time, by a steady increase in the share of employment in services, and by a hump-shaped pattern for the share of employment in manufacturing. That is, the typical process of sectoral reallocation involves an increase in the share of employment in manufacturing in the early stages of the reallocation process, followed by a decrease in the later stages.[11]

Our panel data covers countries at very different stages in the process of structural transformation. For instance, our data includes countries that in 1960 have more than 70 percent of their employment in agriculture (e.g., Turkey and Bolivia), as well as countries that in the same year have shares of employment in agriculture below 10 percent (e.g., the United Kingdom, Netherlands, and the United States). Despite this diversity in the stage

[10] See, for instance, Kuznets (1966), Maddison (1980), among others.

[11] In this paper we refer to manufacturing and industry interchangeably. In the appendix we describe in detail our definition of sectors in the data.

of structural transformation across the sample, all countries follow a common process of structural transformation, characterized by the features discussed above. First, all countries exhibit declining shares of employment in agriculture, even the most advanced countries in this process, such as the United Kingdom and the United States.[12] Second, countries at an early stage of the process of structural transformation exhibit a hump-shaped share of employment in industry, while this share is decreasing for countries at a more advanced stage. Finally, all countries exhibit increasing shares of employment in services. To illustrate these features, Figure 2 plots sectoral shares of employment for Korea, Greece, Spain, and the United Kingdom.[13]

The processes of structural transformation observed in our sample suggest two additional observations. First, the lag in the structural transformation observed across countries is systematically related to the level of development: poor countries are the ones with the highest shares of employment in agriculture, while rich countries are the ones with the lowest shares. (See, for instance, Gollin, Parente, and Rogerson, 2007, and Restuccia, Yang, and Zhu, 2007, for a detailed documentation of this fact across a wider range of countries.) Second, our data suggests the basic tendency for countries that start the process of structural transformation later to accomplish a given amount of labor reallocation faster than those countries that initiated this process earlier.[14]

[12]We focus on shares of employment across sectors because of the lack of sectoral data on average hours of work. We also abstract from movements in the employment to population ratio. However, the employment ratio is remarkably stable over time for most countries in our sample. In the model in section 3 we do consider hours of work at the aggregate level since average hours have changed substantially over time for some countries.

[13]An appendix available from the authors documents the process of structural transformation for all countries in our data set.

[14]For instance, according to the Historical Statistics of the United States, the distribution of employment in the United States circa 1870 resembles that of Portugal in 1950. By 1948 the sectoral shares in the United States were 0.10, 0.34, and 0.56, levels that Portugal reached sometime during the 90's. Although Portugal is lagging behind the process of structural transformation in the United States, it has accomplished about the same reallocation of labor across sectors in less than half the time (39 years as opposed to 89 years in the United States). See Duarte and Restuccia (2007) for a detailed documentation of these observations.

2.2 Sectoral Labor Productivity Growth

For the United States, the annualized growth rate of labor productivity between 1956 and 2000 has been highest in agriculture (4.0 percent), second in industry (2.4 percent), and lowest in services (1.5 percent).[15] This ranking of growth rates of labor productivity across sectors is observed in 23 out of the 29 countries in our sample and in all countries but Venezuela the growth rate in services is the smallest. Nevertheless, there is an enormous variation in sectoral labor productivity growth across countries.

Figure 3 plots the annualized growth rate of labor productivity in each sector against the annualized growth rate of aggregate labor productivity for all countries in our data set. The sectoral growth rate of the United States in each panel is identified by the horizontal dashed line while the vertical dashed line marks the growth rate of aggregate productivity of the United States. This figure documents the tendency for countries to feature higher growth rates of labor productivity in agriculture and manufacturing compared to services. For instance, in our panel, the average growth rates in agriculture and manufacturing are 4.1 and 3.1 percent while the average growth rate in services is 1.3 percent. In addition, note that the cross-country variation in labor productivity growth is higher in agriculture and manufacturing than in services (with standard deviations of 1.6, 1.7, and 1).

Figure 3 also illustrates that countries with low relative aggregate labor productivity growth tend to have low productivity growth in all sectors (e.g., Latin American countries) while countries with high relative aggregate labor productivity growth tend to have higher productivity growth in agriculture and, specially, industry than the United States (e.g., European countries, Japan, and Korea). Interestingly, note that for countries that grew faster than the United States in aggregate productivity, labor productivity growth in services is at or below the U.S. level with only a few exceptions. The fact is that most countries have observed a lower growth rate of labor productivity in services than the United States. These features of the data motivate the counterfactual exercises we perform in section 5.

[15] Annualized growth rates over the period t to $t+T$ are computed as $\left(\frac{A_{i,t+T}}{A_{i,t}}\right)^{1/T} - 1$.

3 Economic Environment

We develop a simple model of the structural transformation of an economy where at each date three goods are produced: agriculture, manufacturing, and services. Following Rogerson (2007), labor reallocation across sectors is driven by two forces: an income effect due to non-homothetic preferences and a substitution effect due to differential productivity growth between manufacturing and services. We calibrate a benchmark economy to U.S. data from 1956 to 2000 and show that this basic framework captures the salient features of the structural transformation in the United States for the calibrated period.

3.1 Description

Production At each date there are three goods produced: agriculture (a), manufacturing (m), and services (s) according to the following constant returns to scale production functions:

$$Y_i = A_i L_i, \qquad i \in \{a, m, s\}, \tag{1}$$

where Y_i is output in sector i, L_i is labor allocated to production in sector i, and A_i is a sector-specific technology parameter. When comparing our model to data, we associate the labor input L_i with the share of total hours allocated to sector i. Because of the lack of sectoral data on hours we allocate total hours by the share of employment in each sector (i.e., our identification assumption is that hours of work are the same across sectors but move over time according to aggregate hours in the data).

We assume that there is a continuum of homogeneous firms in each sector that are competitive in output and factor markets. At each date, given the price of good-i output p_i and wages w, a representative firm in sector i solves:

$$\max_{L_i \geq 0} \{p_i A_i Li - w L_i\}. \tag{2}$$

Households The economy is populated by an infinitely-lived representative household of constant size. Without loss of generality we normalize the population size to one. The household has preferences over consumption goods as follows:

$$\sum_{t=0}^{\infty} \beta^t u(c_t, c_{a,t}), \quad \beta \in (0,1),$$

where $c_{a,t}$ is the consumption of agricultural goods at date t and c_t is the consumption of a composite of manufacturing and service goods at date t. The per-period utility is given by:

$$u(c_t, c_{a,t}) = \log(c_t) + V(c_{a,t}),$$

where $V(c_{a,t})$ is non-homothetic. In particular, we assume that V is such that there is a subsistence level of agricultural goods $\bar{a}$ below which the household cannot survive. This feature of preferences has a long tradition in the development literature and it has been emphasized as a quantitatively important feature leading to the movement of labor away from agriculture in the process of structural transformation.[16] Following Laitner (2000) and Gollin, Parente, and Rogerson (2002), we further simplify the specification of V by assuming that households only care to consume the subsistence amount $\bar{a}$. Formally, $V(c_a) = -\infty$ when $c_a < \bar{a}$, and $V(c_a) = \min\{c_a, \bar{a}\}$ when $c_a \geq \bar{a}$. This feature of preferences makes our analysis tractable. Nevertheless, as we discuss in subsection 3.3 and section 4, this simple preference specification reproduces the time behavior of the share of employment in agriculture in the data remarkably well.

The composite consumption good c_t is given by:

$$c_t = \left[b c_{m,t}^{\rho} + (1-b)(c_{s,t} + \bar{s})^{\rho} \right]^{\frac{1}{\rho}},$$

where $\bar{s} > 0$, $b \in (0,1)$, and $\rho < 1$. Given $\bar{s}$, these preferences imply that the income elasticity of service goods is greater than one. The parameter $\bar{s}$ can be interpreted as a constant level of production of service goods at home. Our approach to modeling the home sector for services is reduced form. Rogerson (2007) considers a generalization of this feature where

[16] See, for instance, Echevarria (1997), Laitner (2000), Kongsamut, Rebelo, and Xie (2001), Caselli and Coleman (2001), Gollin, Parente, and Rogerson (2002), and Restuccia, Yang, and Zhu (2007).

people can allocate time to market and non-market production of service goods. However, we argue that our simplification is not as restrictive as it may first appear since we abstract from the allocation of time between market and non-market activities. Our focus is on the determination of aggregate productivity from the allocation of time across market sectors.

At each date and given prices, the household chooses consumption of each good to maximize the per period utility subject to the budget constraint. Formally,

$$\max_{c_i \geq 0} \left\{ \log \left[b c_m^{\rho} + (1-b)(c_s + \bar{s})^{\rho} \right]^{\frac{1}{\rho}} + V(c_a) \right\}, \tag{3}$$

subject to

$$p_a c_a + p_m c_m + p_s c_s = w.$$

In what follows we normalize the wage rate to one.

Market Clearing The demand for labor from firms must equal the exogenous supply of labor by households at every date:

$$L_a + L_m + L_s = 1. \tag{4}$$

Also, at each date, the market for each good produced must clear:

$$c_a = Y_a, \quad c_m = Y_m, \quad c_s = Y_s. \tag{5}$$

3.2 Equilibrium

A *competitive equilibrium* is a set of prices $\{p_a, p_m, p_s\}$, allocations $\{c_a, c_m, c_s\}$ for the household, and allocations $\{L_a, L_m, L_s\}$ for firms such that: (i) Given prices, firm's allocations $\{L_a, L_m, L_s\}$ solve the firm's problem in (2), (ii) Given prices, household's allocations $\{c_a, c_m, c_s\}$ solve the household's problem in (3), and (iii) markets clear: equations (4) and (5) hold.

The first order condition from the firm's problem implies that the benefit and cost of a marginal unit of labor must be equal. This condition implies that prices of goods are inversely related to productivity:

$$p_i = \frac{1}{A_i}, \tag{6}$$

since the wage rate is normalized to one.

Our specification of $V(c_a)$ implies that $c_a = \bar{a}$ and, therefore, the resource constraint of agricultural goods implies that the labor allocation in agriculture is determined solely by the subsistence constraint and labor productivity in agriculture. That is, labor in agriculture must satisfy:

$$L_a = \frac{\bar{a}}{A_a}. \tag{7}$$

The first-order conditions for consumption of manufacturing and service goods imply:

$$\frac{b}{(1-b)} \left(\frac{c_m}{c_s + \bar{s}} \right)^{\rho - 1} = \frac{p_m}{p_s}.$$

This equation can be re-written as:

$$L_m = \frac{(1 - L_a) + \frac{\bar{s}}{A_s}}{1 + x}, \tag{8}$$

where

$$x \equiv \left(\frac{b}{1-b} \right)^{\frac{1}{\rho - 1}} \left(\frac{A_m}{A_s} \right)^{\frac{\rho}{\rho - 1}},$$

and L_a is given by (7). Equation (8) reflects the two forces that drive labor reallocation between manufacturing and services in the model. First, suppose that preferences are homothetic (i.e., $\bar{s} = 0$). In this case, $L_s/L_m = x$ and differential productivity growth in manufacturing relative to services is the only source of labor reallocation between these two sectors (through movements in x) as long as ρ is not equal to zero. In particular, when $\bar{s} = 0$, the model can be consistent with the observed labor reallocation from manufacturing into services as labor productivity grows in the manufacturing sector relative to services if the elasticity of substitution between these goods is low ($\rho < 0$). Second, suppose that $\bar{s} > 0$ (i.e., preferences are non-homothetic) and that labor productivity grows at the same rate in manufacturing and services or that $\rho = 0$ (i.e., x is constant). In this case, for a given share of labor in agriculture, productivity improvements lead to the reallocation of labor from manufacturing into services (services are more income-elastic). The model allows both channels to be operating during the structural transformation.

3.3 Calibration

We calibrate a benchmark economy to U.S. data for the period from 1956 to 2000. Our calibration strategy involves selecting parameter values so that the equilibrium of the model matches the salient features of the structural transformation for the United States during this period. We assume that a period in the model is one year. We need to select parameters values for b, ρ, $\bar{a}$, $\bar{s}$, and the time series of productivity for each sector $A_{i,t}$ for t from 1956 to 2000 and $i \in \{a, m, s\}$. Table 1 reports a summary of calibrated parameters and targets.

Table 1: Parameter Values and U.S. Data Targets

Parameter	Value	Target
$A_{i,1956}$	1.0	Normalization
$\{A_{a,t}\}_{t=1957}^{2000}$	$\{\cdot\}$	Productivity Growth in Agriculture
$\{A_{m,t}\}_{t=1957}^{2000}$	$\{\cdot\}$	Productivity Growth in Industry
$\{A_{s,t}\}_{t=1957}^{2000}$	$\{\cdot\}$	Productivity Growth in Services
$\bar{a}$	0.10	Employment in Agriculture 1956
$\bar{s}$	0.76	Employment in Industry 1956
b	0.04	Employment in Industry 1957-2000
ρ	-1.5	Aggregate Productivity Growth

We proceed as follows. First, we normalize productivity levels across sectors to one in 1956, i.e., $A_{i,1956} = 1$ for all $i \in \{a, m, s\}$. Given this normalization, we use data on sectoral labor productivity growth in the United States to obtain the time paths of sectoral productivity. Given $A_{a,1956} = 1$ we choose $\bar{a}$ to match the share of employment in agriculture in the data for the United States in 1956.

Second, we restrict $\bar{s}$, b, and ρ to match the share of employment in manufacturing over time and the annualized growth rate of aggregate productivity. Given ρ and b, $\bar{s}$ is chosen to match the share of employment in manufacturing in the United States in 1956. Then b is chosen so that, given the time path of labor productivity in industry relative to services, the model roughly matches the time path for the share of employment in manufacturing. Since ρ determines how much relative productivity growth is needed to produce a given reallocation of labor across sectors, ρ produces different patterns of aggregate productivity growth. Hence, we select ρ to match the annualized growth rate of aggregate labor productivity. The annualized labor productivity growth in the United States between 1956 and 2000 is 2.0 percent in PWT6.1.

The shares of employment implied by our model are reported in Figure 4 (dotted lines), together with data on the shares of employment in the United States (solid lines). The equilibrium sectoral employment shares implied by the model match closely the process of structural transformation in the United States during the sample period. The model implies a fall in the share of employment in manufacturing from about 38 percent in 1956 to 25 percent in 2000, while the employment share in services increases from about 53 to 72 percent during this period. Notice that even though the calibration only targets the share of employment in agriculture in 1956, the simple preference specification for agricultural goods (such that agents only care to consume the level $\bar{a}$) together with data on labor productivity growth in agriculture implies an equilibrium employment share in agriculture over time that is remarkably close to the data.

We find that, given the observed time path of sectoral labor productivity in the United States, the observed process of labor reallocation between manufacturing and services could not be accomplished in the model without an income elasticity greater than one in services. If we set $\bar{s} = 0$, all else equal, then the model implies lower employment shares in industry (and higher employment shares in services) than in the data and lower growth rate of aggregate productivity. Instead, if we set $\rho = 0$, all else equal, then the model implies slightly more labor reallocation to services (and less to industry) than the data and slightly lower annualized growth rate of labor productivity.

An implication of the model is that the price of agricultural goods relative to manufacturing goods is given by the ratio of labor productivity in these two sectors:

$$\frac{p_a}{p_m} = \frac{A_m}{A_a}. \tag{9}$$

Given the sectoral labor productivity growth in the data for the United States, the model implies that the relative price p_a/p_m falls from a normalized level of 1 in 1956 to about 0.5 in 2000. This fall in the relative price of agriculture is consistent with data for the implicit price deflators for agriculture and manufacturing between 1971 and 2004, although the relative price of agriculture falls somewhat more in the data than in the model.[17]

4 Quantitative Analysis

In this section, we assess the quantitative role of the structural transformation and sectoral labor productivity in determining aggregate productivity outcomes across countries. In this analysis, we maintain preference parameters as in the benchmark economy and proceed in two steps. First, we use the model to restrict relative sectoral labor productivity in the first period across countries.[18] Second, using data on sectoral labor productivity growth in each country, the model implies time paths for sectoral employment and relative aggregate labor productivity for each country. We then perform a counterfactual analysis to assess the role of sectoral productivity growth in the reallocation of labor and aggregate productivity outcomes.

4.1 Relative Sectoral Productivity Levels

We use the model to restrict the levels of labor productivity in agriculture, industry, and services relative to those in the United States for the first year in the sample for each country. Maintaining preference parameters, we choose the three relative labor productivity levels for

[17]The price data is obtained from the World Development Indicators and is consistent with the sectoral definitions for labor productivity.

[18]In this analysis, we adjust $\bar{s}$ by the level of relative labor productivity in services in the first period for each country. Although not modeled explicitly, one interpretation of $\bar{s}$ is as service goods produced at home. Therefore, $\bar{s}$ cannot be invariant to large changes in productivity levels in services.

each country to match 3 targets from the data in the first year in the sample: (1) the share of employment in agriculture, (2) the share of employment in manufacturing (and together with (1) the model therefore matches the share of employment in services), and (3) aggregate labor productivity relative to the United States from PWT6.1.

Figure 5 plots the average level of sectoral relative labor productivity for each quintile of aggregate productivity in the first year. The model implies that relative sectoral productivity in the first year tends to be lower in poorer countries than in richer countries, but particularly so in agriculture and services. In fact, the model implies that the dispersion of relative productivity in agriculture and services is much larger than in manufacturing. In the first year, the 6 poorest countries have relative productivity in agriculture and services around 20 and 15 percent while the 6 richest countries have relative productivity in these sectors around 88 and 93 percent. In contrast, for manufacturing, average relative productivity of the 6 poorest countries in the first year is 36 percent and that of the 6 richest countries is 82 percent.

The levels of sectoral relative labor productivity implied by the model for the first year together with observed growth rates of sectoral labor productivity in each country imply time paths for sectoral relative productivity for each country. Figure 6 plots the average level of sectoral relative labor productivity in the first and last years for each quintile of aggregate productivity in the first year. We note that, on average, the countries in the top 3 quintiles experienced substantial gains in productivity in agriculture and manufacturing relative to the United States. In sharp contrast, on average, labor productivity in services in countries in the top 2 quintiles declined relative to the United States during the sample period. These features are suggestive of the results we will discuss in the next subsection. For example, all countries in the third quintile experienced a fast catch-up to the United States during their sample period and high growth rates of labor productivity in agriculture and industry.[19] In the next section we study the role of these high growth rates of sectoral labor productivity in explaining the catch-up in aggregate productivity. In addition, note that all countries in the top quintile (and most countries in the forth quintile) are developed economies that have,

[19]These countries are Spain, Austria, Italy, Finland, and Belgium.

at some point, stagnated or declined relative to the United States in the recent decades.[20] Note that these economies not only have lower relative levels of labor productivity in services than the United States but they also observed a lower growth rate of labor productivity in this sector. As these economies allocate an increasing share of employment to services, low relative labor productivity in this sector dampens aggregate productivity. In the next section we quantitatively study this mechanism and show it plays an important role in accounting for all the stagnation and decline episodes of many developed economies in recent decades.

Some empirical studies provide internationally-comparable measures of labor productivity for some sectors and some countries. These studies typically provide estimates for narrow sectoral definitions at a given point in time. The productivity differences in agriculture implied by the model are qualitatively consistent with the differences in output per worker in agriculture between rich and poor countries implied by PPP-adjusted data from FAO for 1985.[21] The OECD and MGI provide studies at different levels of sectoral disaggregation for manufacturing. These studies report relative productivity for a relatively small set of countries and most studies report estimates only at one point in time. One exception is Pilat (1996). This study reports relative labor productivity levels in manufacturing for 1960, 1973, 1985, and 1995 for 13 countries. While the implied relative labor productivity levels in industry in our model tend to be higher than those reported in this study, the patterns of relative productivity are consistent for most countries. Finally, consistent with our findings, several studies report that the Unites States has higher levels and higher growth rates of labor productivity in service sectors than other developed countries and that lower labor productivity in service sectors compared to manufacturing is pervasive.[22]

As a first pass in assessing the importance of labor reallocation across sectors, we can use the time paths of relative labor productivity across sectors and countries to ask how

[20] In addition to the United States, these countries are New Zealand, Canada, Australia, Sweden, and Netherlands.

[21] See Restuccia, Yang, and Zhu (2007).

[22] Baily, Farrell, and Remes (2005) estimate that, with the exception of mobile telecommunications, France and Germany had lower relative productivity levels in 2000 and had lower growth rates of labor productivity between 1992 and 2000 for a set of narrowly-defined service sectors. In another study, MGI reports relative productivity levels in services and manufacturing for Turkey of 0.33 and 0.43 in 2000. The productivity levels for services and industry implied by our model are 0.08 and 0.44.

much of the changes in aggregate labor productivity over time can be accounted for by movements in the share of employment across sectors. To illustrate these changes, Figure 7 shows the time path of relative aggregate labor productivity together with the implied path for the case of no labor reallocation for Italy, Spain, the United Kingdom, and France. For Italy and Spain, the 60's and 70's were characterized by substantial catch-up in aggregate labor productivity to the U.S. level. During this period, labor was being reallocated from agriculture into industry and services, both sectors observing higher relative productivity than agriculture. Therefore, if labor reallocation had not occurred the catch-up would have been much lower during this period. However, from the late 70's and early 80's onwards the labor reallocation actually implies a slow-down in the catch-up process since most labor reallocation is going from industry to services, a sector with lower relative productivity. Strong labor reallocation towards services and a lower relative productivity in this sector also account for the negative impact of labor reallocation on aggregate productivity in the United Kingdom and in France's later sample period.

These calculations are only suggestive of the possible implications of labor reallocation across sectors for aggregate productivity. Since the movements of labor across sectors are endogenous to changes in sectoral labor productivity, a model of these endogenous movements is needed to make the assessment of a counterfactual situation in terms of labor productivity growth. In the next subsection we do just that.

4.2 The Structural Transformation and Counterfactuals

Given the time paths for sectoral labor productivity, the model has time-series implications for shares of employment across sectors and aggregate labor productivity for each country (4 time series). The model reproduces the salient features of the structural transformation and aggregate productivity over time across countries. To illustrate this performance, Figure 8 reports the percentage change in the average value of each time series in the first 5 years of the country's sample period relative to its average value in the last 5 years both in the data and in the model for each country. The model replicates well the basic time trends in sectoral shares of employment and relative aggregate productivity observed in the data, particularly so for the share of employment in agriculture and relative aggregate productivity. Figure 8 attests the ability of the simple preference specification for agricultural goods in replicating the basic trend observed for the share of employment in agriculture across a large cross-section of countries. Regarding the share of employment in industry, the model tends to imply a lower growth over the time series compared to the data, particularly so for less developed economies where the share of employment in industry increased over the sample period. Conversely, the model tends to imply a higher growth of the share of employment in services over the sample period than that observed in the data. This feature of the model suggests that, specially for less developed countries, frictions to the reallocation of labor between manufacturing and services are important in accounting for their structural transformation.

While in most cases the model does well in reproducing the time series in the data, in some countries, modifications to the simple model would be required in order to better account for the process of structural transformation and relative aggregate productivity (see, for instance, Duarte and Restuccia, 2007, for an application of wedges across sectors in Portugal). These richer environments, however, would require country-specific analysis. We instead maintain our simple model specification and perform counterfactual experiments for countries in which the model does well in reproducing the time series of employment and aggregate productivity. We leave the other interesting country-specific experiences for further and future research.

We construct a series of counterfactuals aimed at assessing the role of the structural transformation and relative sectoral labor productivity on aggregate productivity experiences across countries. We focus on two sets of counterfactuals. The first set focuses on catch-up growth experiences that are associated with high relative growth rates of labor productivity in industry. The second set focuses on decline, stagnation, and slow-down growth experiences that are associated with low productivity in the service sector.

To start, we consider the growth experience of Spain. In 1960, aggregate labor productivity in Spain was 42 percent of that of the United States; by the mid 70's, relative aggregate productivity had increased to 65 percent but it stagnated during the 80's and 90's. During this period, relative productivity in industry increased from 49 to more than 71 percent. In the first counterfactual we ask about the aggregate implications of this substantial growth in labor productivity in industry. We compute the equilibrium implications for the allocation of employment and aggregate productivity under the scenario that labor productivity in industry had grown at the same rate as in the United States. Table 2 reports the equilibrium implications of this counterfactual scenario. While there is no substantial change in labor reallocation, relative aggregate productivity increases to only 54 percent. Figure 9 documents the time path of relative aggregate productivity in Spain (implied by the model and in the data) and for the counterfactual.

Table 2: Counterfactuals – Spain

	Agriculture	Industry	Services	Aggregate
Model:				
$L_{i,1960}$	0.42	0.32	0.26	–
$L_{i,2000}$	0.04	0.23	0.73	–
Relative $A_{i,1960}$	0.25	0.49	0.59	0.42
Relative $A_{i,2000}$	0.58	0.71	0.53	0.60
Counterfactual – industry:				
$L_{i,2000}$	0.04	0.25	0.71	–
Relative $A_{i,2000}$	0.58	0.49	0.53	0.54
Counterfactual – services:				
$L_{i,2000}$	0.04	0.24	0.72	–
Relative $A_{i,2000}$	0.58	0.71	0.71	0.72

Counterfactual (1) assumes a growth rate of labor productivity in industry in Spain of 2.4 percent (the annualized growth rate in the United States) instead of the observed 3.4 percent. Counterfactual (2) assumes a growth rate of labor productivity in services in Spain of 2.1 percent instead of the observed 1.3 percent so it achieves relative productivity in services of 71 percent by 2000.

We perform identical counterfactuals for other countries that have observed both a substantial catch-up in relative productivity as well as high relative productivity growth in industry. Figure 9 reports the aggregate productivity implications of identical productivity growth in industry as in the United States for Norway, Austria, and Belgium. Notice that these countries were between 40 to 60 percent of aggregate labor productivity of the United States in 1960. These countries also experienced relatively high labor productivity growth in industry as documented previously and, for some of these countries, productivity growth in agriculture promoted a substantial reallocation of labor away from agriculture. We conclude from these counterfactual experiments that relative productivity growth in industry accounts for more than 50 percent of relative aggregate productivity catch-up in these countries.

Next, we consider a different set of counterfactuals aimed at assessing the importance of productivity growth in services for experiences of decline, stagnation, and slow-down among developed economies. We start with Canada. Canada is among the countries that is closest to the United States in terms of the process of structural transformation. In 1956, labor productivity in Canada was 92 percent of that in the United States. By 2000, it had declined to 83 percent. As a result of low labor productivity growth in services, productivity in services declined from 98 to 73 percent of the level in the United States during this period (see Table 2. We ask about the aggregate implications of labor productivity in services in Canada growing at the same rate as in the United States during this period (and thus Canada maintaining the relative productivity level of services in 1956). The results of this counterfactual are reported in Table 3. This counterfactual would have implied a further increase in relative aggregate productivity from 92 percent to 99 percent in 2000 (Figure 10 reports the implied time path).

New Zealand is another country that has recently observed a decline in relative aggregate productivity, from close to 1 in 1971 to less than 70 percent in 2000. In 1971, relative labor productivity in services in New Zealand was about 96 percent. However, between 1971 and 2000 productivity growth in services in New Zealand was -0.24 percent and by 2000 relative productivity in services was 60 percent. If New Zealand had the same productivity growth in services as in the United States, relative aggregate productivity would have declined much less, to slightly less than 90 percent (see Figure 10).

Spain after the mid 70's and the United Kingdom are two experiences of relative stagnation and slow-down. Both these countries observed an important catch-up in relative productivity in industry during the entire period (Spain from 49 to 71 percent and the

Table 3: Counterfactual − Canada

	Agriculture	Industry	Services	Aggregate
Model:				
$L_{i,1956}$	0.16	0.35	0.49	–
$L_{i,2000}$	0.05	0.22	0.73	–
Relative $A_{i,1956}$	0.64	0.97	0.98	0.92
Relative $A_{i,2000}$	0.53	1.11	0.73	0.83
Counterfactual:				
$L_{i,2000}$	0.05	0.23	0.72	–
Relative $A_{i,2000}$	0.53	1.11	0.98	0.99

Counterfactual assumes a growth rate of labor productivity in services to maintain the relative productivity with the United States in 1956. This requires a growth rate of 1.5 percent observed in the United States during the period as opposed to the observed 0.96 percent in Canada.

United Kingdom from 40 to 91 percent) but both countries failed to catch-up in services (it fell from 59 to 53 percent in Spain and from 70 to 67 percent in the United Kingdom). In these two cases we ask about the aggregate implications of services catching up to 71 and 91 percent of the level of the United States.[23] The time path of these counterfactuals are reported in Figure 10. Both the stagnation and slow-down in relative aggregate productivity in Spain and the United Kingdom are accounted for by relative slow growth in services. Note that these countries were above 60 percent of aggregate labor productivity of the United States in 1960. For all these countries there was a substantial reallocation of labor towards services and low relative labor productivity growth in services. Overall, low relative productivity growth in services accounts for all of the decline, stagnation, or slow-down of relative aggregate labor productivity in these countries.

We conclude with these counterfactuals that, while productivity convergence in manufacturing (and agriculture) are essential in the first stages of the process of structural transformation, the poor relative performance in services has determined a slowdown and

[23]For the United Kingdom, the annualized growth rate of labor productivity in services observed between 1956 and 2000 was 1.4 percent while the implied growth rate in this counterfactual is 2.1 percent. For Spain, see the notes to Table 2.

decline in aggregate productivity for the more advanced countries in this process.

5 Conclusions

We documented the reallocation of labor over time between agriculture, manufacturing, and services and the growth rate of sectoral labor productivity across countries. While countries are going through a common process of structural transformation, we found that there is substantial lag differences in this process. We also found that most countries tend to observe low productivity growth in services compared to agriculture or manufacturing even though there is a big variation in sectoral labor productivity growth across countries.

Using a model of the structural transformation that is calibrated to the experience of the United States, we showed that sectoral differences in labor productivity can account for differences in the process of structural transformation and aggregate productivity across countries. We found that sectoral labor productivity differences across countries are large and systematic both at a point in time and over time. In particular, labor productivity differences between rich and poor countries are large in agriculture and services and smaller in manufacturing, and all countries have a lower level of productivity in services than the Unites States. An implication of these findings is that, as countries move through the process of structural transformation, relative aggregate labor productivity can first increase (as labor moves from agriculture to manufacturing) and later stagnate or decline (as labor moves from agriculture and manufacturing to services).

This paper highlights the role of labor productivity differences across sectors for aggregate productivity. In particular, whereas labor productivity in manufacturing accounts for more than 50 percent of the catch-up in aggregate productivity in developing countries, labor productivity in services accounts for most of the stagnation and decline in aggregate productivity in more developed economies. Thus, understanding the sources of cross-country differences in labor productivity across sectors is crucial. What factors contribute to cross-country differences in labor productivity across sectors? Why were countries able to catch-up in manufacturing productivity and not in services? What are the barriers that prevent other developed economies to sustain growth rates of labor productivity in services as high as in the United States? How are trade openness and regulation related to these productivity differences across countries? We leave these important questions for future research.

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A Data Sources and Definitions

We build a panel data of 29 countries on PPP-adjusted GDP per hour (in constant prices), and employment and output per worker (in constant prices) for agriculture, industry, and services. The countries covered in our data set are Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Denmark, Spain, Finland, France, Greece, Ireland, Italy, Japan, Korea, Mexico, Netherlands, Norway, New Zealand, Portugal, Sweden, Turkey, Venezuela, United Kingdom, and United States. The time period covered varies across countries, but it ranges from 1956 to 2000 for most countries.

A.1 Aggregate Data

We use data from Penn World Tables version 6.1. (see Heston, Summers, and Aten, 2002)[24] to construct annual time series of PPP-adjusted GDP in constant prices, PPP-adjusted GDP per worker in constant prices, and total employment for each country. These three series cover the period 1950 to 2000 for all countries with the exception of Chile, Greece, Sweden (1951-2000), and Korea (1953-2000).

We construct total employment L using the variables Population (POP), Real GDP Chain per worker (RGDPWOK), and Real GDP Chain per capita (RGDPCH) as $L = (RGDPCH \times POP)/RGDPWOK$.

We construct PPP-adjusted GDP in constant prices using the variables Real GDP per capita in Constant Prices (RGDPL) and Population (POP) as $GDP = RGDPL \times POP$. The series for PPP-adjusted GDP per worker in constant prices is computed as $YL = GDP/L$.

We use aggregate data on annual hours worked per employee from Total Economy Database, maintained by Groningen Growth and Development Center, to construct annual time series of PPP-adjusted GDP per hour in constant prices for each country. The series for hours cover the period 1950 to 2002 for all countries, with the exception of Korea (1963-2005). We construct PPP-adjusted GDP per hour in constant prices as $YLh = YL/H$, where H is annual hours worked by employee.

A.2 Sectoral Data

We obtain annual data on employment and output for agriculture, industry, and services for all the countries listed above. The sectors are defined by the International Standard Industrial Classification, revision 3 (ISIC III) definitions, with agriculture corresponding to ISIC divisions 1-5 (agriculture, forestry, hunting, and fishing), industry to ISIC divisions 10-45 (mining, manufacturing, construction, electricity, water, and gas), and services to ISIC divisions 50-99 (wholesale and retail trade – including hotels and restaurants, transport, and government, financial, professional, and personal services such as education, health care, and real estate services).

[24] Heston, Alan, Robert Summers, and Bettina Aten, Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002.

A.2.1 Value Added by Sector

Value added by sector is obtained by combining data from the World Bank's World Development Indicators online[25] and historical data from the OECD National Accounts publications for the following countries: Austria, Australia, Belgium, Canada, Denmark, Finland, France, Greece, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Turkey, United Kingdom, and United States.

The data series from the World Bank's World Development Indicators are agriculture-value added, industry-value added, and services-value added. All series are measured in constant local currency units (base year 1995). These series cover the following time periods: Australia (1971-2000), Austria (1971-2000), Belgium (1971-2000), Canada (1971-2000), Denmark (1966-2000), Finland (1960-2000), France (1971-2000), Greece (1960-2000), Italy (1970-2000), Japan (1960-2000), Korea (1972-2000), Netherlands (1971-2000), New Zealand (1977-2000), Norway (1971-2000), Portugal (1971-2000), Spain (1971-2000), Sweden (1971-2000), Turkey (1968-2000), United Kingdom (1971-2000), and United States (1971-2000).

The series from the World Bank's World Development Indicators are extended backwards using historical data from the OECD National Accounts publications, except for Greece, Japan, and Korea.[26] A combination of three OECD publications was used: National Accounts of OECD Countries (1950-1968), National Accounts of OECD Countries (1950-1961), and National Accounts of OECD Countries (1960-1977). The primary resource was the book covering the period from 1950 to 1968. We compute growth rates of the OECD data for corresponding variables for years prior to those available through the World Bank and apply them to the World Bank series. After this step the first year of data on output per worker by sector for this set of countries is: Australia (1964), Austria (1960), Belgium (1956), Canada (1956), Denmark (1960), Finland (1959), France (1970), Greece (1960) Italy (1956), Japan (1960), Korea (1972), Netherlands (1960), New Zealand (1971), Norway (1956), Portugal (1956), Spain (1960), Sweden (1960), Turkey (1960), United Kingdom (1956), and United States (1956).

Data on value added by sector at constant prices for Ireland are obtained from the national accounts division of the Central Statistics Office of Ireland. These series cover the period from 1970 to 1995 and are extended backwards to 1958 using historical data from the OECD National Accounts publications (as described above).

Data on value added by sector for all Latin American countries in our data set (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, and Venezuela) are obtained from CEPALHISTAT: Database of Historical Data, maintained by CEPAL.[27] This database has data on "GDP by branch of economic activity, constant prices" (base year by country) for 10 sectors and it covers the period 1950-2003 for all countries. These data are aggregated

[25] "World Development Indicators," World Bank. (1960-2004). Available on-line: <http://devdata.worldbank.org/dataonline/>.

[26] "National Accounts of OECD Countries" (1950-1968); "National Accounts of OECD Countries," (Detailed Tables, Volume II, 1950-1961); "National Accounts of OECD Countries," (Detailed Tables, Volume II, 1960-1977).

[27] "CEPALHISTAT: Database of Historical Data," Comisión Económica para América Latina y el Caribe. Available on-line: <http://websie.eclac.cl/sisgen/consulta.asp.>

into agriculture, industry, and services using ISIC III definitions.

We compute the sectoral shares of total value added using the series of value-added by sector, as

$$sVA_i = \frac{VA_i}{\sum_i VA_i}, \quad i = a, m, s,$$

where VA_i is value added in sector i. We multiply these shares by the series of GDP in constant prices computed from the Penn World Tables to obtain series of output by sector. Although the growth rates of aggregate GDP for each country implied by the aggregation of sectoral value added and the PWT6.1 are close for most countries, the adjustment above guarantees that the growth rates of aggregated series and PWT series match up exactly. We note however that even though the resulting sectoral outputs for these calculations are in the same currency units (constant 1996 international dollars) we do not use these levels in our calculations, only their implied sectoral growth rates. The reason is that these implied levels of output across sectors depend on a PPP-conversion factor that differs across countries but that is common across sectors. There is substantial evidence that the PPP-conversion factors differ systematically across sectors in development. We instead use the model to back-out sector-specific PPP-conversion factors across countries.

A.2.2 Employment by Sector

The sectoral employment data is obtained from a variety of sources as well. We compile series of total civilian employment in each broad sector, as defined by ISIC III. Aggregations of the sub-sectors were completed by the agency providing the data, except in the case of the Latin American data.

The OECD Database on Labor Force Statistics online[28] is used to obtain data for the following countries: Australia, Belgium, Canada, Finland, France, Ireland, Italy, Japan, Korea, New Zealand, Norway, Spain, Turkey, United Kingdom, and United States from 1956 to 2003. Data for Austria, Denmark, Greece, and Sweden is obtained from Source OECD, Outlooks and Annuals, Labor Force Statistics. These series were available from 1960 to 2004.[29] Data for Portugal on sectoral employment is obtained from the data set Séries Longas para a Economia Portuguesa of the Bank of Portugal.[30] The data is aggregated into the same three broad sectors. The data covers the period 1953-1995. The data for the Latin American countries is obtained from CEPALHISTAT: Database of Historical Data, and it covers the period 1950-2003. These data is defined for 10 broad sectors, which we aggregate into the three broad sectors using the ISIC III definitions.

We use the sectoral employment data to construct shares of employment by sector for

[28] "Labour Force Statistics," Source OECD: Outlooks & Annuals (1960-2004). Available on-line: <http://hermia.sourceoecd.org/vl=718832/cl=16/nw=1/rpsv/outlook_annuals.htm.>

[29] "Labor Market Statistics Database," OECD Corporate Data Environment (1956-2003). Available online: <http://www1.oecd.org/scripts/cde/members/lfsdataauthenticate.asp.>

[30] "Séries Longas para a Economia Portuguesa pós II Guerra Mundial," Banco de Portugal. Available online: <http://www.bportugal.pt/publish/serlong/serlong_p.htm.>

each country as

$$sL_i = \frac{L_i}{\sum_i L_i}, \quad i = a, m, s,$$

where L_i is employment in sector i. We multiply these shares by the series of total employment from the Penn World Tables to obtain series of employment by sector.

The lack of sectoral data on hours of work prevents us from constructing series for the share of total hours. Nevertheless, we use total hours and divide them according to the constructed shares of employment. The implicity assumption is that hours of work are constant across sectors but vary over time according to total hours. Hence, hours by sector are obtained by multiplying total hours by the sector share of employment.

We construct value added per hour by sector by dividing, for each sector, our constructed series of output with the corresponding series of hours.

All series are trended using the Hodrick-Prescott filter with a smoothing parameter $\lambda =$ 100 before any ratios are computed.

Figure 1: Relative GDP per Hour – Some Countries

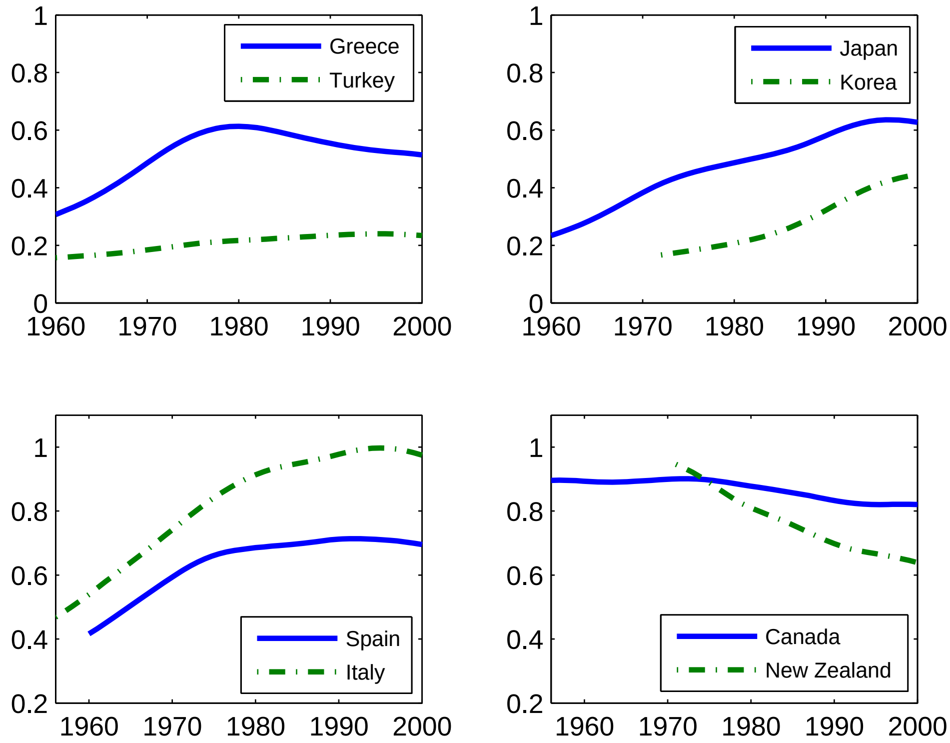


Figure 2: Shares of Employment

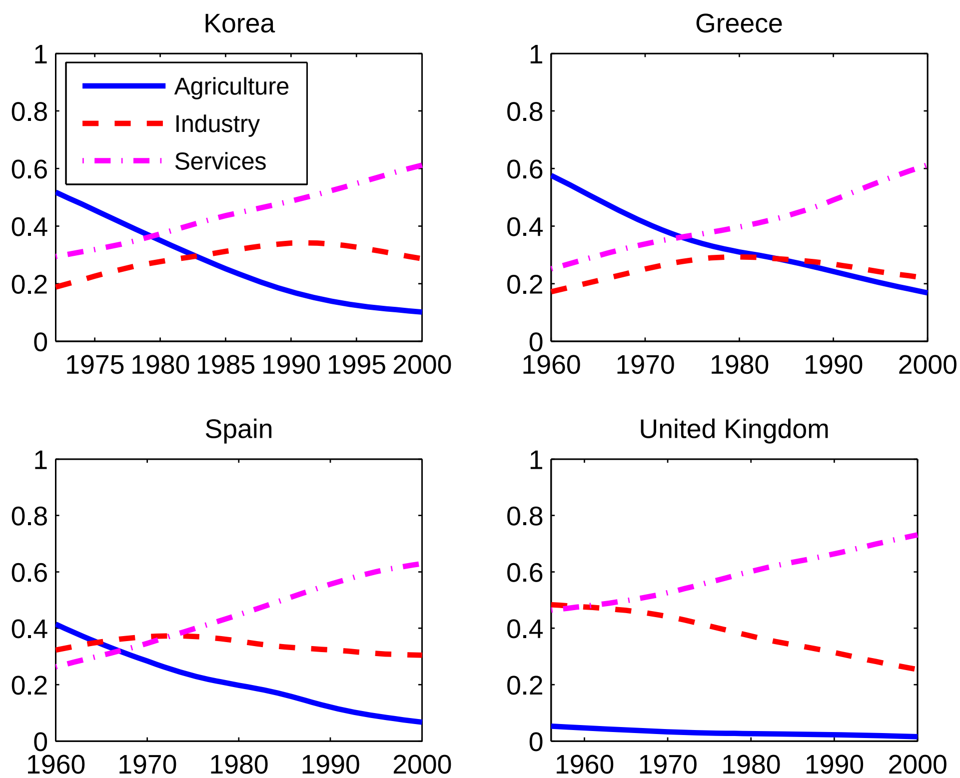
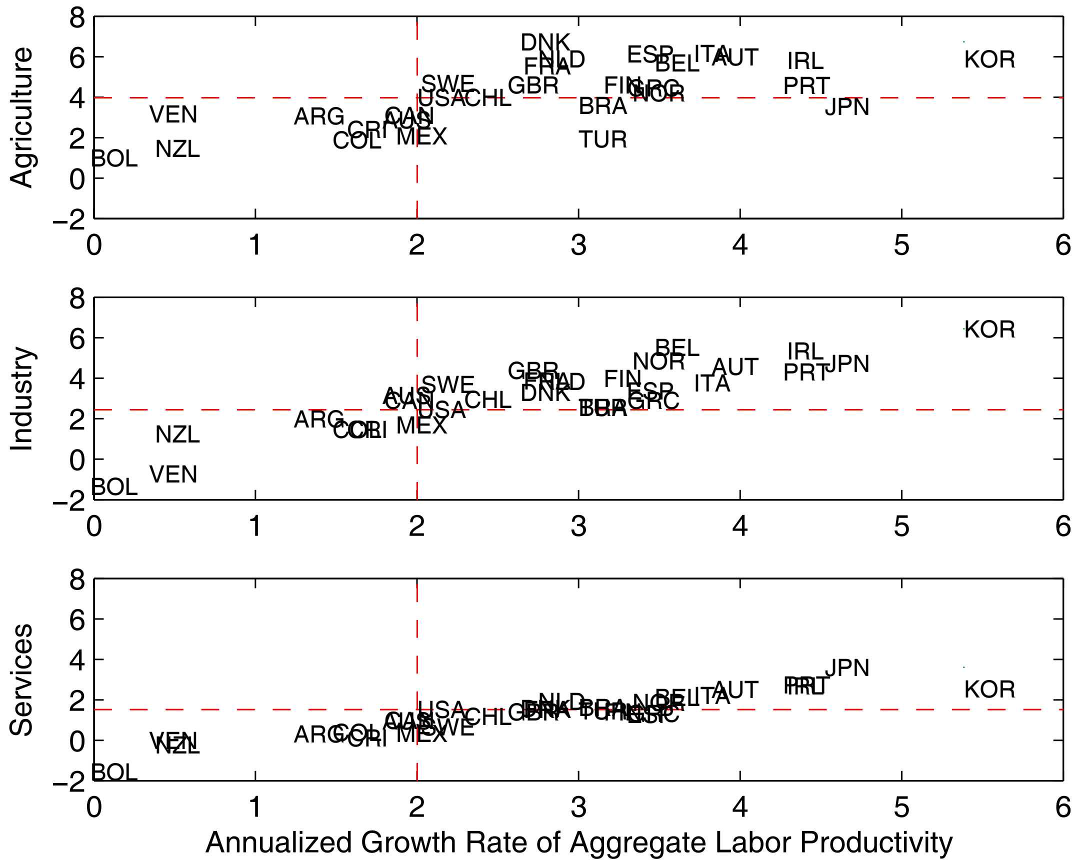


Figure 3: Sectoral Growth Rates of Labor Productivity (%)



Note: Annualized growth rates during the sample period for each country. The horizontal lines indicate the sectoral growth rates observed in the United States and the vertical line indicates the aggregate growth rate of the United States.

Figure 4: Share of Employment by Sector - Model vs. U.S. Data

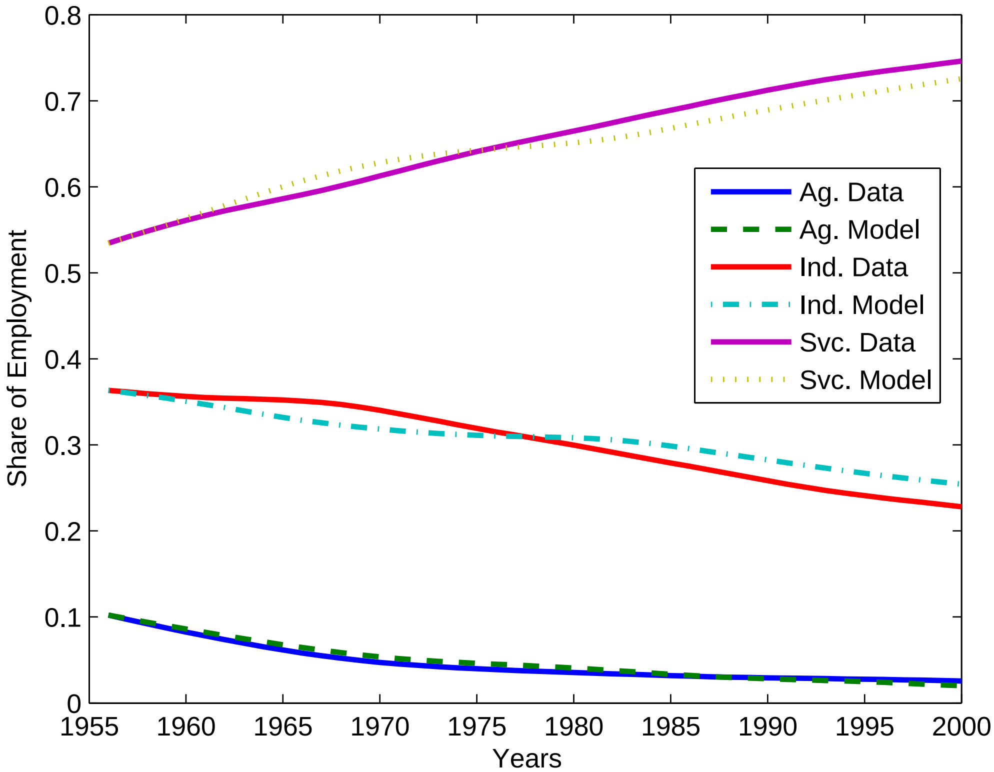


Figure 5: Relative Labor Productivity across Sectors - first year

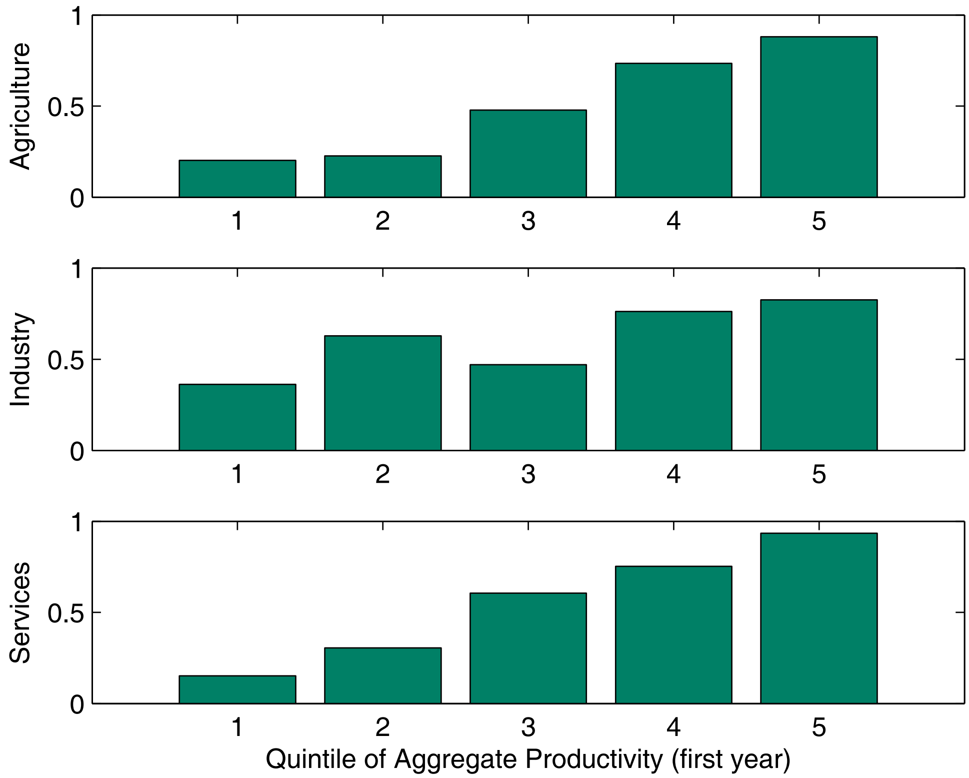


Figure 6: Relative Labor Productivity across Sectors - first and last years

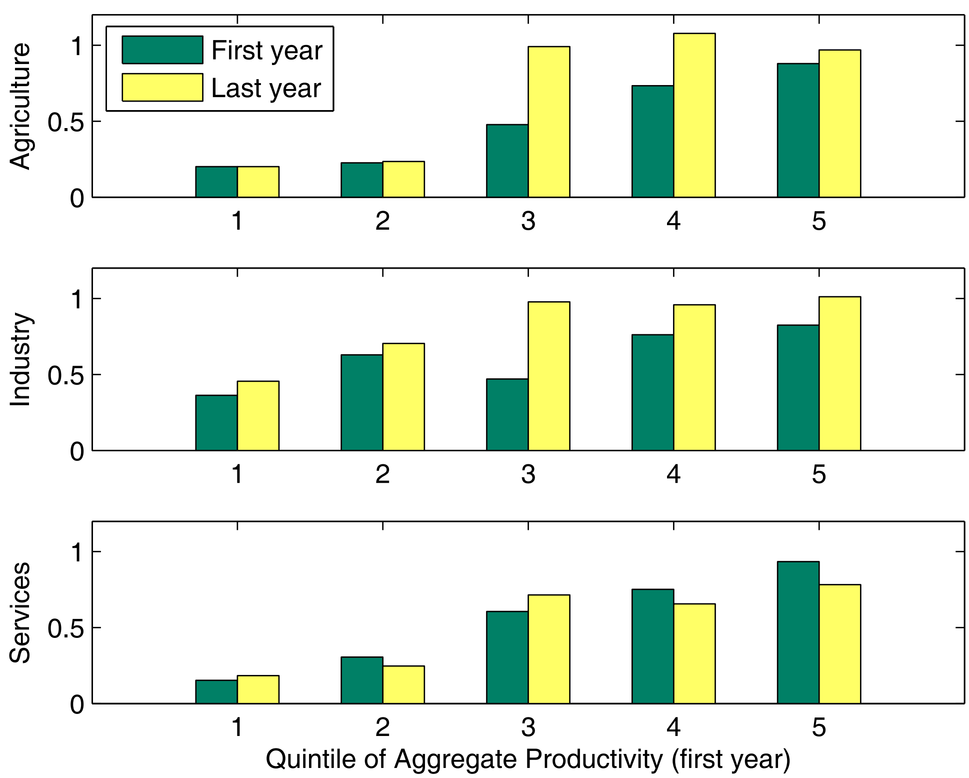


Figure 7: Importance of Labor Reallocation – some countries

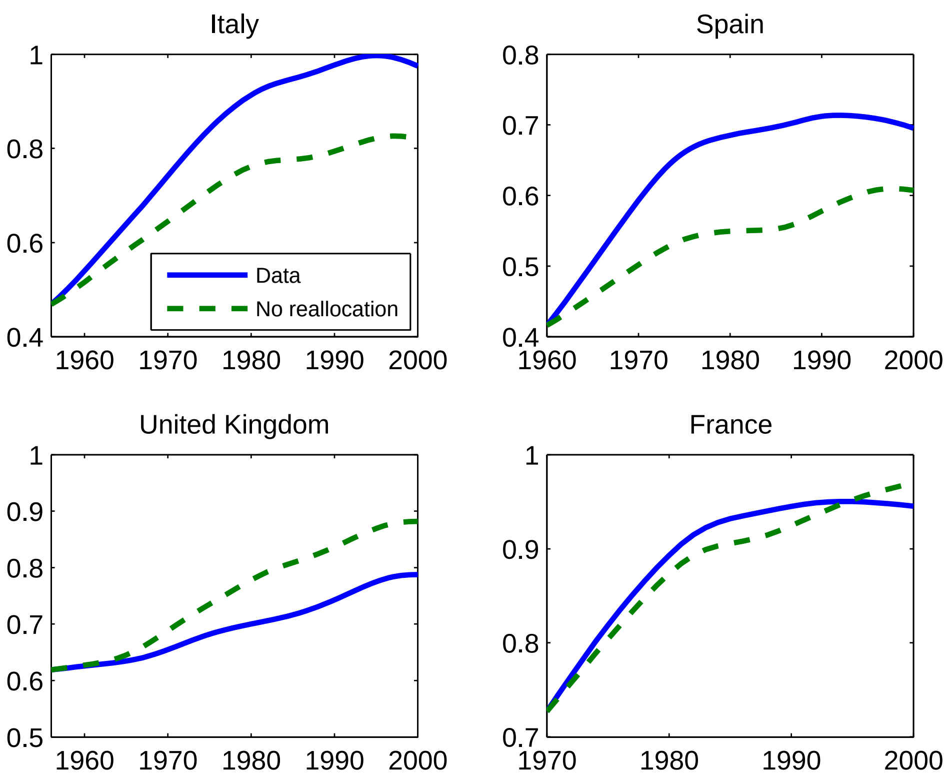
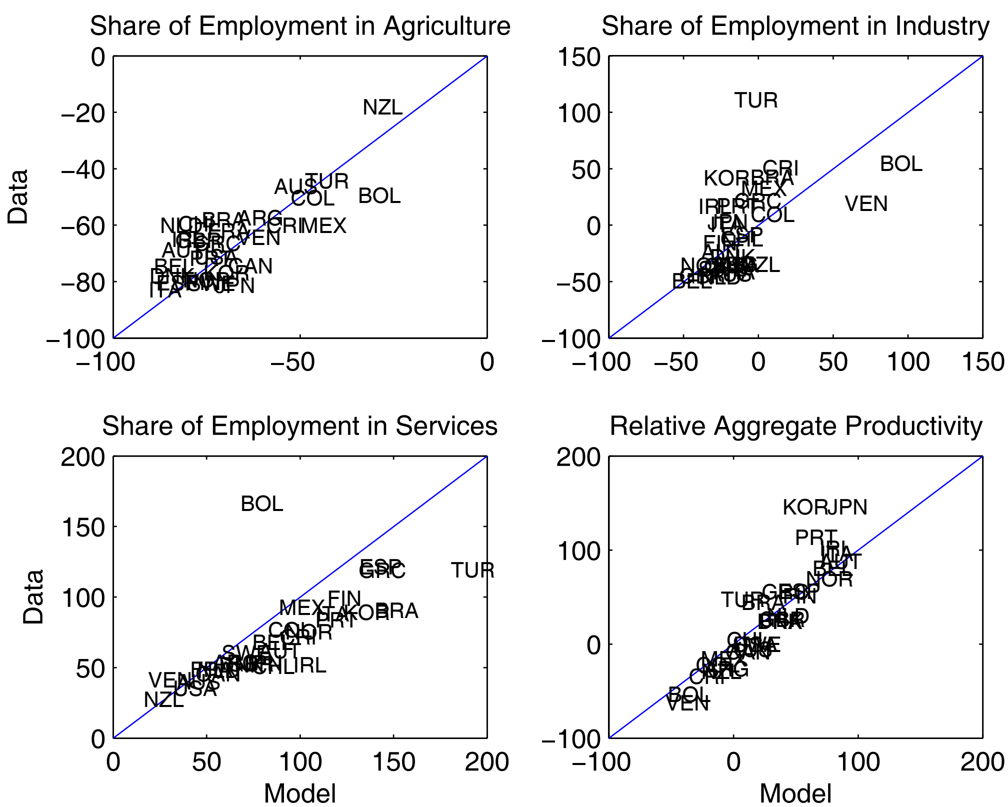


Figure 8: Model vs. Data Across Countries



Each plot reports the percentage change in the variable's average value in the first 5 years relative to its average value in the last 5 years in the data and in the model.

Figure 9: Counterfactuals – Importance of Industry

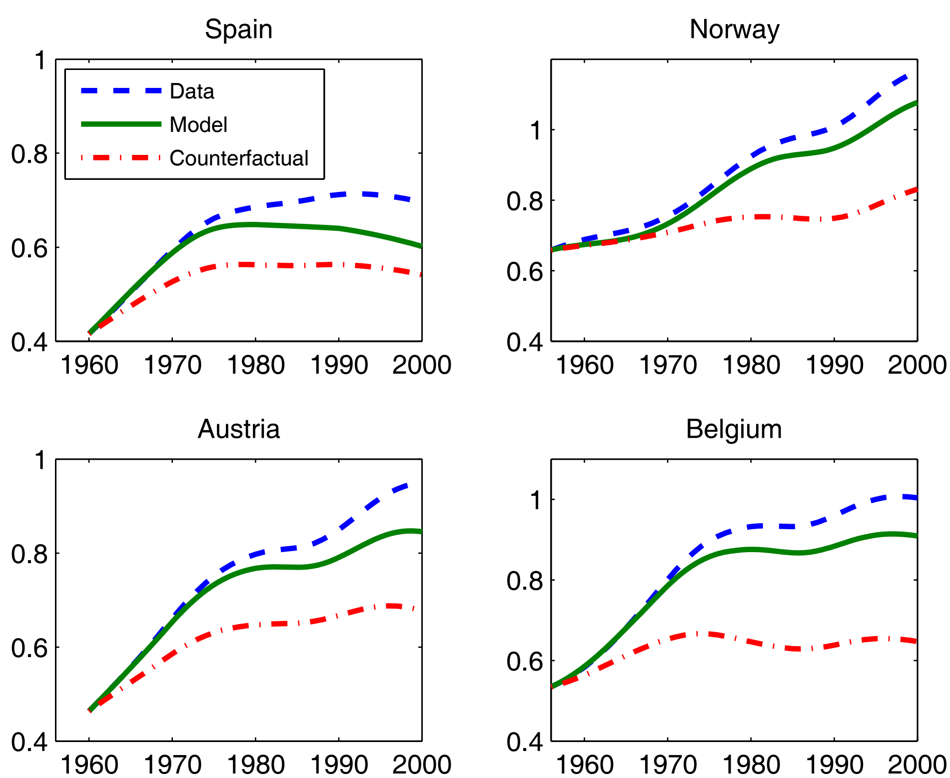


Figure 10: Counterfactuals – Importance of Services