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Total Factor Productivity Growth and Structural Change in Transition Economies

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Abstract

TFP differences are the dominant source of cross-country income differences, including the differences between the new members of the EU and the older ones. In this paper, we estimate TFP growth in transition economies at the sectoral level, thus enabling us to estimate the extent to which structural change in the transition economies contributes to, or hinders, their efforts to catch up to the income levels of the older EU members. Due to the difficulties in measuring the capital stock of the transition economies, we develop a model that estimates sectoral TFPs from data on sectoral employment and GDP per capita. We compute TFP in industry, services and agriculture in a sample of transition economies and we compare these levels of TFP to those of Austria. While transition economies have lower TFP levels than does Austria, TFP growth for the transition countries surpasses that of Austria. Inter-sectoral movement of labor does not play a large role in aggregate TFP growth over our sample period.

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1. Introduction

A key task for the transition economies that have recently joined the European Union is real convergence, the catching up with the per capita income levels of the older and more developed members. Although some observers have stressed that this process would require extensive investment in physical and human capital (Blanchard (1997), Buiter (2000)), the growth accounting literature suggests that these are not likely to be the decisive forces leading to convergence. This literature, from Solow (1957) to Prescott (1998) and Hall and Jones (1999), stresses that economic growth as well as inter-county differences in per capita income are largely due to changes or differences in total factor productivity, with the accumulation of physical and human capital playing only a subsidiary role.[1]

The ability of the new EU members to generate significant gains in TFP should not be taken for granted. The USSR and the countries of East Europe saw gains in TFP came to a virtual halt in the early 1980s, if not even before then, an event unprecedented among countries at such a level of development.[2] The first to note the slowdown in TFP growth in the USSR was Kaplan (1968) who showed that, for any plausible parameter values of a Cobb-Douglas production function, Soviet TFP growth was falling toward zero. The literature took a different turn due to Weitzman (1970), who attributed the slowdown to a low elasticity of substitution between capital and labor, a finding that, of course, improves

[1] Thus, Hall and Jones deconstruct the "the 35-fold difference in output per worker between the United States and Niger. Different capital intensities in the two countries contributed a factor of 1.5 to the income differences, while different levels of educational attainment contributed a factor of 3.1. The remaining difference- a factor of 7.7-remains as the productivity residual." (Hall and Jones (1999), p. 83). Prescott (1998) reaches a similar conclusion without assuming a specific form of the production function. See also, Klenow and Rodriguez-Clare (1997), Hendricks (2002); Parente and Prescott (1994, 2000) and Caselli (2005).

[2] See Ofer (1987) and Brada (1985) for surveys of the literature on this topic.

TFP growth given the slow growth of the labor force and the rapid growth of the capital stock in the communist countries. Easterly and Fisher (1995) continued this insistence on the low elasticity of substitution explanation for Soviet growth retardation, but, in the face of the critique of their empirical work by Beare (2008), they are forced to accept the "conclusion that the rate of technical progress declined over the course of the history of the former Soviet Union" (Easterly and Fisher (2008), p. 147).

Although the results of similar research for East Europe were couched in a variety of terminologies and methodologies, such as "extensive" vs. "intensive" growth, difficulty in substitution of capital for labor, changes in technical efficiency, etc., researchers in both the West and in the communist countries themselves came to more or less that same conclusion, namely that, by the start of the 1980s, the only sources of growth in the USSR and East Europe were increases in capital and hours worked, with TFP growth non-existent or negative.

Moreover, it is not at all evident that the forces that retarded TFP growth so severely during the late communist era have been eliminated by the process of transition. If the sources of TFP growth or of differences in TFP levels are not influenced by short-term changes in policies, institutions or economic systems, then the transition economies would be consigned to being second-class members of the EU for a long time.[3]

A second and related aspect of real convergence is structural convergence. The communist regimes in East Europe had followed a development strategy that favored

[3] The literature on the causes of TFP differentials is quite unsettled in this respect. Some authors, including Prescott (1998), take the view that a country's TFP levels are subject to rather rapid change due to institutional and policy changes, while others, such as Hall and Jones (1999) and Frankel and Romer (1999) suggest that rather immutable factors such a legal origins, geography, etc. are important determinants of TFP levels, which means that rapid TFP change in the East European countries would be difficult if not impossible.

industry and agriculture at the expense of services. Thus, these countries entered the transition, and EU membership, with employment shares in industry and agriculture that were much larger than those found in market economies at similar levels of development and with service sectors that had much lower shares of employment than were to be found in comparable market economies (Gregory (1970), Ofer (1976)). These disparities carried over to the shares of these sectors in aggregate output as well. As these economies turned to the market to allocate resources, in most of them the service sector expanded quite dramatically while agriculture and industry have lost employment share (European Union (2006)) although all of these economies continue to exhibit higher labor shares in agriculture and industry and lower shares in services than are to be found in the older EU member counties. Whether this structural difference is a legacy of communist policies or whether it simply reflects the fact that structural change in favor if services at the expense of agriculture and industry occurs with rising per capita incomes is unclear. In either case, as we shall see, structural change is more rapid in the new EU member countries so it remains to be seen whether this faster and ongoing shift of resources between sectors is be an important contributor to, or retardant of, aggregate TFP growth, which could be the case if there are significant differences in TFP levels or growth between the three sectors.

In principle, it should be possible to undertake growth accounting exercises for the transition economies at the sectoral level, thus measuring TFP levels and their evolution over time. However, in dealing with the transition economies we face a fundamental problem due to difficulties with the estimates of the capital stock. The transition from socialism to capitalism effectively destroyed a large, but unknown, part of the capital stock. Part of the destruction was physical; factories were abandoned and equipment was

scrapped or thrown away. Part of the destruction was what might be called "moral", meaning that the huge changes in the structure of demand and the wholesale acquisition of new and more productive technologies from the West that occurred in the course of transition devalued, or accelerated the depreciation of, much of the communist-era capital stock (Campos and Coricelli (2002)). While numerous studies of this phenomenon have produced estimates of surprisingly large declines in Russian and East European capital stock over the course of the transition, these estimates differ widely in their magnitude as well as in the methodologies utilized and in the assumptions driving their application to individual countries. Needless to say, such wide divergences in these "unofficial" estimates of the capital stock lead to wide divergences in estimates of TFP growth and levels in the course of transition. Absent plausible official estimates of sectoral and even aggregate capital stocks and the wide divergence in the unofficial estimates, as well as the lack of sectoral capital stock data, we propose to measure sectoral TFPs without recourse to capital stock data.[4]

A similar data limitation for developing countries has led researchers to develop indirect methods for estimating sectoral TFPs. The existing literature uses cross-section prices in a multi-sector growth model to infer sectoral relative TFPs.[5] In this paper we use a three-sector model developed by Bah (2007) to infer sectoral TFP time series for a sample of transition economies. This kind of model also has been used by Rogerson (2007) to analyze labor market outcomes in Europe.

[4] Izumov and Vahaly (2006, 2008) provide a survey of the issues and the literature on the transition-era capital stock as well as a methodologically consistent set of estimates of the "adjusted" capital stocks of the Russian and former CIS economies. While we do not examine these economies in our paper, the gaps between official and adjusted estimates of the capital stock and their implications for TFP estimates shown by these studies are instructive.

[5] See Herrendorf and Valentinyi (2006); Hsieh and Klenow (2007).

The rest of the paper is organized as follows. Section 2 describes the model, characterizes the competitive equilibrium and calibrates the model to the US economy. Section 3 applies the model to Austria and to a sample of transition economies countries to demonstrate differences in sectoral TFP levels and their change relative to Austria, an EU member with a per capita output close to the (old member) EU average and with some similarities in size and location with a number of the transition economies. Section 4 draws out some policy implications of our findings.

2. A Three-Sector Model of Structural Transformation

Below, we present a model developed by Bah (2007). The model has three sectors: agriculture, industry and services. Total factor productivity growth causes resources to shift across sectors according to the process of structural transformation first described by Kuznets (1966).

2.1 The Model

We assume closed economies to simplify the analysis and avoid the complications that arise with the introduction of trade.

Preferences

There is a representative household who lives forever and we normalize its size to 1 for simplicity. The household supplies labor inelastically to the three sectors. The instantaneous utility is given by:

$$U(\Phi_t A_t) = \begin{cases} A_t & if \quad A_t < \overline{A} \\ \log(\Phi_t) + \overline{A} & if \quad A_t \geq \overline{A} \end{cases} \qquad (1)$$

where A_t is the agricultural good and Φ_t is a composite consumption good defined as a CES aggregate of the industrial good (M_t) and the services (S_t).

$$\Phi_t = \left(\lambda M_t^{\frac{\varepsilon-1}{\varepsilon}} + (1-\lambda) S_t^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}} \quad (2)$$

Lifetime utility is given by:

$$\sum_{5=0}^{\infty} \beta^t U(\Phi_t, A_t) \quad (3)$$

where β is the discount factor.

This specification of preferences implies that the economy specializes in agriculture until the subsistence level $\overline{A}$ is reached. Moreover, the economy will never produce more agricultural good than $\overline{A}$.

Endowments

In each period the household is endowed with one unit of time. Also, the household is endowed with initial capital stock at time 0 and the total land for the economy. We normalize the size of land to 1 and assume that land does not depreciate.

Technologies

Agriculture:

The agricultural good is produced using a Cobb-Douglas production function with labor (*N*) and land (*L*) as the only inputs.[6] The agricultural good is only used for consumption so the resource constraint is given by:

$$A_t = A_{at} N_{at}^{\alpha} L_t^{1-\alpha} \quad (4)$$

where

[6] This formulation assumes that capital is not used in the agricultural technology. In the application of the model, the effect of agricultural capital is implicitly captured by agricultural TFP.

$$A_{at} = A_a (1 + \gamma_{at})^t \quad (5)$$

The TFP parameters A_a, γ_{at} are assumed to be country specific.

Industry and services:

The industry and service sectors produce output using standard Cobb-Douglas production functions with capital and labor as inputs. We follow the literature and assume identical capital shares in both sectors. The industrial sector's output is used for consumption (M_t) in the composite good and investment (X_t). The industry sector resource constraint is:

$$M_t + X_t = A_{mt} K_{mt}^{\theta} N_{mt}^{1-\theta} \quad (6)$$

where

$$A_{mt} = A_m (1 + \gamma_{mt})^t \quad (7)$$

The law of motion of the aggregate capital stock (K_t) in the economy is given by:

$$K_{t+1} = (1 - \delta) K_t + X_t \quad (8)$$

where δ is the depreciation rate.

The output of the service sector is only used for consumption through the composite good. Therefore, the service sector resource constraint is given by:

$$S_t = A_{st} K_{st}^{\theta} N_{st}^{1-\theta} \quad (9)$$

where

$$A_{st} = A_s (1 + \gamma_{st})^t \quad (10)$$

In the equations above, the TFP parameters (A_m, γ_{mt}, A_s and γ_{st}) are also assumed to be country specific. We may expect that a country's institutions and policies affect the productivity in each of these economic sectors.

2.2 Equilibrium

Given that there are no distortions in this economy, the competitive equilibrium allocations can be obtained by solving a social planner's problem. However, we should note that this specification of preferences implies that the economy specializes in the production of agriculture as long as $A_a(1+\gamma_a)^t < \overline{A}$. Once $A_a(1+\gamma_{at})^t \geq \overline{A}$, the economy begins the production of industrial good and services. This corresponds to the start of structural transformation and we will solve for the competitive equilibrium from this point on. Let T be the first period in which the economy can move labor out of agriculture. From period T on, a social planner chooses the allocations $(K_t, K_{mt}, K_{st}, N_{at}, N_{mt}, N_{st}, S_t, L_t)$ to solve the following maximization problem:

$$\max \sum_{t=T}^{\infty} \beta^{t-T} (\log(\Phi_t) + \overline{A}$$

s.t.

$$\Phi_t = \left(\lambda M_t^{\frac{\varepsilon-1}{\varepsilon}} + (1-\lambda) S_t^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

$$\overline{A} = A_{at} N_{at}^{\alpha} L_t^{1-\alpha}$$

$$S_t = A_{st} K_{st}^{\theta} N_{st}^{1-\theta}$$

$$M_t + \mathrm{X_t} = A_{mt} K_{mt}^{\theta} N_{mt}^{1-\theta}$$

$$K_{t+1} = (1-\delta) K_t + X_t$$

$$K_{mt} + K_{st} = K_t$$

$$N_{at} + N_{mt} + N_{st} = 1$$

We refer the reader to Bah (2007) for the details on how to solve this model.

Labor in agriculture is given by:

$$N_{at} = \left(\frac{\overline{A}}{A_{at}} \right)^{\frac{1}{\alpha}} \tag{11}$$

Let $N_t = 1 - N_{at}$ be the total time that can be allocated between the industry and service sectors. The aggregate capital stock is given by the following dynamic equation:

$$K_{t+1} = A_{mt} \left(\frac{K_t}{N_t} \right)^{\theta} N_t + (1-\delta) K_t - \beta \left[1 - \delta + \theta A_{mt} \left(\frac{K_t}{N_t} \right)^{\theta-1} \right]$$

$$\left[A_{mt-1} \left(\frac{K_{t-1}}{N_{t-1}} \right)^{\theta} N_{t-1} + (1-\delta) K_{t-1} - K_t \right] \tag{12}$$

Once capital is known, the quantity of labor used in the service sector is given by:

$$N_{st} = \frac{C_t}{A_{mt} \left(\frac{K_t}{N_t} \right)^{\theta} \left[1 + \left(\frac{\lambda}{1-\lambda} \right)^{\varepsilon} \left(\frac{A_{st,}}{A_{mt}} \right)^{1-\varepsilon} \right]} \tag{13}$$

where C_t is the non-agriculture aggregate expenditure and is given by:

$$C_t = A_{mt} \left(\frac{K_t}{N_t} \right)^{\theta} N_t + (1-\delta) K_t - K_{t+1} \tag{14}$$

The other equilibrium allocations can be easily derived.

2.3 Calibration to the US Economy

In this section, we summarize the calibration procedure.[7] The model is calibrated to match the U.S economy from 1950 to 2000. There are thirteen parameters to calibrate. The productivity levels $A_{i(i=a,m,s)}$ are normalized to 1 in 1950.[8] This corresponds to choosing units. Following the literature, labor's share in agriculture (α) is set to 0.7 and capital's share in industry and services (θ) is set to 0.3.

[7] For details, see Bah (2007). The data sources are explained in Appendix A.
[8] This normalization is over time, not across sectors.

The TFP growth rates for industry and services (γ_m, γ_s) the discount rate β and δ are jointly calibrated to match four averages in the data from 1950 to 2000: average growth rate of GDP per capita, average growth rate of the price of the service good relative to the industrial good, average investment to output ratio and average capital to output ratio.

The growth rate of agricultural TFP (γ_{at}) is chosen such that the model matches the agricultural shares of hours worked in the US. We assume that the growth rate varies each decade starting in 1950. The agricultural subsistence level is equal to the agricultural production in every period after the start of structural transformation. Given that the agricultural TFP is normalized to 1 in 1950, the subsistence level can be easily computed using the shares of hours in agriculture. The last two parameters to calibrate are the elasticity of substitution between the industrial good and services (ε) and the weight of the industrial good in the production of the composite good (λ). These two parameters determine the labor reallocation between the industrial and service sectors. We choose values of ε and λ to minimize the quadratic norm of the difference between the predicted and actual industrial employment shares from 1950 to 2000.

Table 1 summarizes the calibrated parameter values.

Table 1: Calibrated Parameters

A_a	A_m	A_s	$\overline{A}$	α	β	δ	ε	γ_m	γ_s	λ	θ
1	1	1	0.24	0.7	0.975	0.05	0.335	0.019	0.009	0.01	0.3

3. **Estimates of Sectoral TFP in Austria and Selected Transition Economies**

In this section we use the parameters derived from our calibration exercise and data on sectoral labor shares and GDP per capita to estimate the sectoral TFPs for Austria and for nine transition economies: Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, the Slovak Republic and Slovenia, that have joined the European Union.[9] Our analysis covers the period 1995-2005. Although our model is one of sectoral change, which is a long-term phenomenon, as we shall see, the sectoral changes in employment in the transition economies were quite significant even over this shorter period. We use Austria as a standard for comparison because in terms of population and land area it falls within the range of the transition economies in our sample and it also is close geographically to a number of the transition economies.

Table 2: Per Capita Incomes as % of EU-15 Average

Country	1997	2005
Austria	112.9	113.3
Czech Republic	61.9	67.8
Estonia	35.0	51.7
Latvia	29.8	43.1
Lithuania	33.3	47.1
Hungary	45.5	57.2
Poland	40.1	46.0
Slovak Republic	42.3	50.1
Slovenia	64.5	75.0

Source: EU (2006)

Austria's per capita income in 1997 and 2005 exceeded that of the transition countries by a palpable amount (Table 2). Austria is somewhat above the average per

[9] The sectoral employment shares for Romania proved somewhat problematic, and thus we dropped that country from our analysis even though it, too, is now an EU member.

capita GDP for the old EU member countries, and its position relative to other "old" EU members changed very little between 1995 and 2005. The transition economies have gained appreciably in their standing *vis a vis* the EU 15 average, although the gains differ considerably across countries.

In the application of the calibrated model to Austria and the transition countries, we assume all the parameters are the same across countries except the series of sectoral TFP. We use the model to find sectoral TFP series such that, within the framework of the model, we can best replicate the paths of GDP per capita and sectoral employment shares. For agricultural TFP, we use the fact the subsistence level is assumed to be the same in every country. Therefore, for any other country, we can use the US employment shares and calculated agricultural TFP to deduce that country's agricultural TFP. We calculate the agricultural TFPs in 1995, 2000 and 2005 and then assume constant growth between those dates. For the TFP series in industry and services and the initial capital stock, we match GDP per capita relative to the US in 1995, the average GDP per capita growth and labor reallocation from industry between 1995 and 2005.

3.1 Sectoral TFP in Austria

Figure 1 shows the results of our simulation of Austrian per capita GDP growth, sectoral employment and sectoral TFP. The first panel shows per capita GDP, with 1995 normalized to one. The simulated and actual data for GDP per capita are close to each other as are the sectoral employment shares reported in Panel 2. The shares of agriculture and industry in employment have fallen while services employment's share has increased. Overall, structural change in Austria has been relatively slow over the period analyzed. The last panel in the Figure shows that Austrian total factor productivity in industry

relative to US industrial TFP in 1950 was around 2.1 in 1995 and close to 2.4 in 2005. Agriculture and services TFPs in Austria in 1995 were between 1.4 and 1.5 times the corresponding 1950 level in the United States. TFP growth in industry and agriculture was relatively high but TFP growth in the Austrian services sector was very slow.

The ratios of Austrian TFP's to US TFPs should not be taken as indications of the relative productivity in the three sectors of the Austrian economy. While Austrian industry's TFP relative to the 1950 US level is larger than the ratio of Austria's agricultural TFP to the US level, it may be the case that, in 1950, TFP in US agriculture was much higher than was TFP in industry, and that the higher growth of industrial TFP in Austria in the intervening period was insufficient to offset this productivity advantage of agriculture over industry by 1995 or 2005. As a result we are not able it infer from Figure 1 whether the expansion of one of Austria's three sectors at the expense of the other two tends to raise or lower aggregated TFP. By observing the growth rates of TFP in the three sectors, we can, however, determine whether such intersectoral shifts in resources promote aggregate TFP growth by moving more resources into sectors that enjoy faster TFP growth over time. In the case of Austria, the movement of resources from agriculture and industry to services, can be seen as a drag on growth in the sense that resources moved from sectors with high rates of productivity change to one with low TFP growth. Given the slow pace of labor reallocation, the effect is likely to be negligible.

3.2 Sectoral TFP in Transition Economies

In Figures 2-10 we present, in the same format as Figure 1, the simulation results for the transition economies over the period 1995-2005. We first briefly discuss cross-country similarities and differences in the results and then discuss how sectoral TFP levels

and trends influence the convergence of the transition economies to EU levels of per capita GDP. Next we provide an international comparison of sectoral TFPs to investigate whether the aggregate TFP lag implied by the transition economies' lower per capital GDP is due to lower TFPs in all sectors of the economy or whether their lower aggregate TFPs are the result of particularly poor productivity in particular sectors of their economies.

From Panel 1 of these Figures it is evident that per capita incomes in the transition economies grew more rapidly that they did in Austria, something already evident from Table 2. The Baltic Republics made the larges gains in per capita GDP, the Czech Republic the smallest. Panels 2 for the transition economies show the nature and extent of structural change. All countries underwent a similar change in structure that involved the movement of labor out of agriculture and industry and into services.[10] In this sense, structural change in the new EU members mirrors that taking place in the old EU members, even if, looking at the current sectoral distribution of labor the new members lag behind the older ones in the shrinkage of agriculture's and industry's shares of labor and the corresponding growth of services employment.

An important note is that changes in employment shares in the transition economies need to be interpreted in the context of stagnant or even declining total employment. At the outset of the transition, throughout East Europe, employment fell not only because of the so-called transition recession but also because of the systemic transformation from communism, which had policies to ensure that nearly everyone worked, to capitalism. While aggregate output recovered within a few years after the start

[10] A number of countries show a small reversal in that at the end of our period of observation, industry appears to gain labor share at the expense of services. This may be related to large inflows of FDI and the emergence of East Europe as a sourcing point for manufactured goods exports to the EU.

of transition to pre-transition levels and then surpassed them, employment levels have remained significantly below pre-transition levels although they do not differ markedly from those observed in the older EU members.

Examining Panel 3 of Figures 2-10 also shows that the transition economies, like Austria, have low TFPs relative to the US 1950 level in services and that TFP growth in services is relatively slow, although not much worse than in industry. The most productive and dynamic sector appears to be agriculture. Indeed, the Czech Republic, Estonia, Hungary, the Slovak Republic and Slovenia experienced an acceleration of TFP growth in agriculture in the second half of our period of observation.

There are significant differences among the nine transition economies in terms of the efficiency of their sectors relative to 1950 United States sectoral TFP levels. Table 3 ranks the sectors of the new EU member countries relative to US 1950 levels. The situation of industry is least ambiguous; it ranks as best or second best *vis a vis* the US in all countries, and it is never the last sector in rank. For a sector that promotes tradables, thus facing international competition, a sector receiving large amounts of FDI, and a sector that may enjoy some human capital and infrastructure legacies from the communist era, such high rankings are not surprising. The rankings for services are also quite consistent, but poor. It is never the best sector and most often it is the sector that lags all others relative to US TFP. The long neglect of services, the clear shortages that existed in the provision of retail and other such "low productivity" services after the fall of communism, and slowness in developing a modern services sector may all account for this. A lack of internationalization of the services sector may also be a factor. The relative position of agriculture is the most variable of the three sectors. In some countries it comes

closest to US TFP levels, but in other counties it shows the biggest gap. This may reflect real cross-country differences in the productivity of the agrarian sector due to differences in the effectiveness of agricultural reforms, to the dissolution of collective agriculture, land distribution and reform, etc., or it may reflect shortcomings in our model, such as the failure to account for agricultural trade.

Table 3: Rankings of Sectoral TFPs Relative to the US -1950

Country	Ranking
Bulgaria	IND>SER>AGR
Czech Republic	AGR>IND>SER
Estonia	AGR>IND>SER
Hungary	AGR>IND>SER
Latvia	IND>AGR>SER
Lithuania	IND>SER>AGR
Poland	IND>SER>AGR
Slovak Republic	AGR>IND>SER
Slovenia	IND>SER>AGR

3.3 Structural Change and Aggregate TFP Growth

In this subsection we estimate the loss in GDP that results from the structural transformation process. This question is motivated by the fact in all of our countries at least some labor moves among sectors at a faster pace than in the old EU member countries. However, we should note that the process of structural change is a key feature accompanying development. In fact Kuznets (1966) viewed this process as one of six stylized facts of economic development. He noted that in the early stages of development resources move from agriculture into industry and services. In the later stages, resources move from agriculture and industry into services.

To determine whether structural change, either by moving labor form low to high TFP sectors or by moving labor from low to high TFP growth sectors (or *vice versa*) has an important impact on aggregate growth, we compute the model's GDP per capita using the capital stock and TFP series estimated in the above section. However, instead of using the corresponding labor shares from the model, we use the sectoral employment shares given by the data for 1995.[11] Table 4 below summarizes the loss of GDP per capita growth from 1995. The largest loss in potential per capita GDP was in Lithuania, whose per capita GDP in 2005 was 6.55 percent of 1995 per capita GDP less that it would have been with no structural change. This means that annual growth of per capita GDP was a bit less than half a percent slower than it would have been with no structural change. This is not a trivial amount, even when judged against the almost doubling of per capital GDP between 1995 and 2005, but for the other countries the effect of structural change on growth is

Table 4: Loss of GDP per capita due to structural transformation (as % of 1995 GDP per capita)

Country	% Loss
Austria	1.28
Bulgaria	0.95
Czech Republic	2.29
Estonia	3.83
Hungary	2.31
Latvia	4.47
Lithuania	6.55
Poland	2.74
Slovak Republic	4.44

[11] It is important to note that in the model labor reallocation across sectors results from differences in sectoral TFP growth rates and the preference specifications.

Slovenia	3.16

negligible. Thus past and future structural change, even at the accelerated pace seen in the transition economies over the past decade, has a relatively minor impact on the new EU members' ability to catch up with the older EU countries in terms of per capita GDP.

3.4 Sectoral TFP in Comparative Perspective

Our results show that sectoral TFPs have risen in all of the transition economies the sample period, 1995-2005, and that there is relatively rapid structural change taking place in all these countries. This structural transformation follows the Kuznets model of labor transfer from agriculture and industry toward services. However, per capita GDP convergence between the transition economies and the older EU member countries will require the sectoral TFPs of the transition economies to reach the levels of the old member countries, represented here by Austria, which had higher GDP per capita than all transition countries in the period considered. Thus, which sectors are holding back the transition economies is of some interest.

Figure 11 shows the agricultural TFPs of the transition economies relative to Austria's agricultural TFP, which is normalized to one in each year.[12] One transition economy, the Czech Republic, has higher TFP in agriculture than does Austria for the entire sample period, and its agricultural TFP also grew faster than did Austria's. As a result, by the end of our sample period, Czech TFP in agriculture was nearly 20% higher than Austria's. This is not a surprising result because the two countries share a similar continental climate and grow similar crops using similar technologies, but the quality of

[12] For estimates of agricultural productivity in transition economies obtained by means of other methods, see Tonini and Jongeneel (2006) and Lissitsa et al. (2007).

Czech land is higher due to a more favorable topography. Moreover, the Czech Republic has experienced a dismantling of socialist-era collectives and the outflow of part-time and low-productivity labor from agriculture. Three other transition economies, the Slovak Republic, Hungary and Estonia also show remarkable convergence to Austrian TFP levels, with the former two countries surpassing Austria by the end of the sample period and Estonia's TFP nearly equal to that of Austria. These four countries' agrarian sectors thus already operate at productivity levels that are comparable to an old EU member with an above (old EU) average per capita income.

For the other transition economies the picture is less favorable. Slovenia started the period with TFP in agriculture at about three-fourths of Austria's, but its TFP growth failed to match Austria's over the sample period so that, by the end of the sample period, the TFP gap between the two countries had widened. The two Baltic Republics, Latvia and Lithuania have TFP about one half of Austria's and they made only modest progress in closing this productivity gap between 1995 and 2005. Poland and Bulgaria fell farther behind Austria and both have TFPs in agriculture that are less than one half of Austria's. For Poland, its many small, and inefficient, private farms are a likely source of that country's low agricultural TFP.

Figure 12 provides similar comparisons of the transition countries' TFPs in industry to that of Austria. None of the transition economies has an industrial TFP that matches that of Austria. Nevertheless, four transition countries, Estonia, Latvia, Lithuania and Hungary showed large gains in TFP over the sample period, ending with TFPs that are from two-thirds to three-fourths of Austria's. Poland experienced a more gradual convergence to Austria's TFP levels, while the Czech Republic and Slovenia had

relatively high levels of TFP, but failed to keep up with TFP growth in Austria over the sample period. The Slovak Republic and Bulgaria had TFPs in industry that were about one-half of Austria's.[13]

Services TFPs are reported in Figure 13. None of the transition economies matches Austria's services TFP although Slovenia, the Czech Republic and the Slovak Republic are close, but closing the gap only very slowly. The three Baltic Republics and Hungary, while staring at relatively low TFP levels, all made significant improvements in service sector TFP over the sample period. In contrast, Poland and Bulgaria had low TFPs and failed to make much headway in catching up with the other economies.

4. **Conclusions and Policy Implications**

In this paper we have estimated the TFPs of the transition economies that have joined the EU and of a roughly comparable "old" EU member, Austria, which has per capita income that is higher than any of the new members. These differences in per capita income mirror differences in aggregate TFP. However, we are able to show that the differences between Austria and the new EU member countries in aggregate TFP are reflected in differences in sectoral TFP, which on average are also lower than those of Austria. However, the TFP gap between Austria and the new members we observed are not uniform across sectors of the economy. The TFP the gap appears smallest in agriculture and greatest in industry or services depending on the country. Moreover, the new member countries differ in the relative TFP levels of the three sectors.

A second finding is that the transition economies themselves should not be seen as a homogeneous group. There are great TFP differences between them, and perhaps more

[13] The divergence in industrial TFP performance in the transition economies is somewhat surprising. All received massive inflows of FDI, investment rates have not differed much, and general reform measures have been quite similar as well.

troubling, some of them are not improving productivity in one or two sectors, suggesting that catching up with the EU average may prove an impossible task for them.

The structural changes taking place in the transition economies mirror, but appear to be faster than, those taking place in Austria, and, indeed, in virtually all EU member countries. The proportion of the labor force employed in agriculture is falling, as is that of those employed in industry, while services employ the largest and increasing share of the labor force. This structural change is not necessary favorable for the transition economies in the sense that the TFP gap between themselves and Austria is the smallest in agriculture and larger in services and particularly in industry. Nevertheless, we show that the effect of rapid structural change on the growth of per capital income in the new EU members is not large. Indeed, the shrinking of industry in these countries is helpful because the TFP gap between them and Austria is the largest in this sector, suggesting that the problems of industry related to the communist era have not as yet been entirely overcome. The gap between Austria and the transition economies in services TFP is not large for some of the transition countries, but more troubling is that about one half of the transition economies are not catching up with Austria in this key sector. Thus, if there is to be convergence in per capita GDP between the old and the new members of the EU, then measures to improve productivity in services and, perhaps less urgently, in industry will be required.

Unfortunately, while we are able to identify the sectors that seem to contribute the most to the aggregate TFP gap between the new EU members and Austria, this only helps in formulating polices to accelerate convergence in the sense that we can pinpoint the sectors where improvement is most needed. How to improve TFP at either the aggregate or sectoral level remains a contentious subject. Some research suggests that the causes of

cross-country TFP differentials are not amenable to change through short-term policies, while others argue that reducing taxes, liberalizing labor markets, and reducing barriers to the adoption of new technologies play an important role in TFP improvements. In industry, this may require greater labor market flexibility, more FDI, improving management skills and a more favorable regulatory and business climate. In services, greater outlays on education, deregulation and more competition and greater globalization of the service sector may be required to achieve the necessary gains in TFP.

Also noteworthy is that the aggregate TFP growth of each of the transition economies is based on strikingly different TFP dynamics and levels in the three sectors. There is a tendency when discussing the growth and income levels of the transition economies to assume that reforms, liberalization, and greater reliance on the market, as captured by broad indicators of economic reform, such as the EBRD reform index, rankings of "competitiveness", etc., influence the performance of all sectors of the economy in more or less the same way. However, our results suggest that this may not be the case. Countries with broadly similar reform policies and similar reform "scores" have different sectoral TFP levels and dynamics. This suggests that our measures of reforms may be too broad or that policies, which often go unnoticed, play a more important role in determining TFP levels and growth than is commonly thought.

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Appendix A: Data Sources

For the US, the data for GDP per capita, expressed in 1990 international Geary-Khamis dollars, is from the *Historical Statistics for the World Economy: 1-2003 AD* by Maddison. The shares of sectoral hours worked and the price of services relative to industry are from the Groningen 10-sector industry database. We obtained average capital to output ratio and average investment to output ratio from the NIPA tables. The price of services relative to industry is calculated using data from the Gronigen 10-sector industry database. The database shows the value-added of each sector in constant and current prices. The price of a sector is obtained by dividing the value-added in current prices by the value-added in constant prices. For Austria and the transition countries, GDP per capita in constant 2000 PPP dollars and the sectoral employment shares are from World Development Indicators Online Database.

Appendix B: Figures

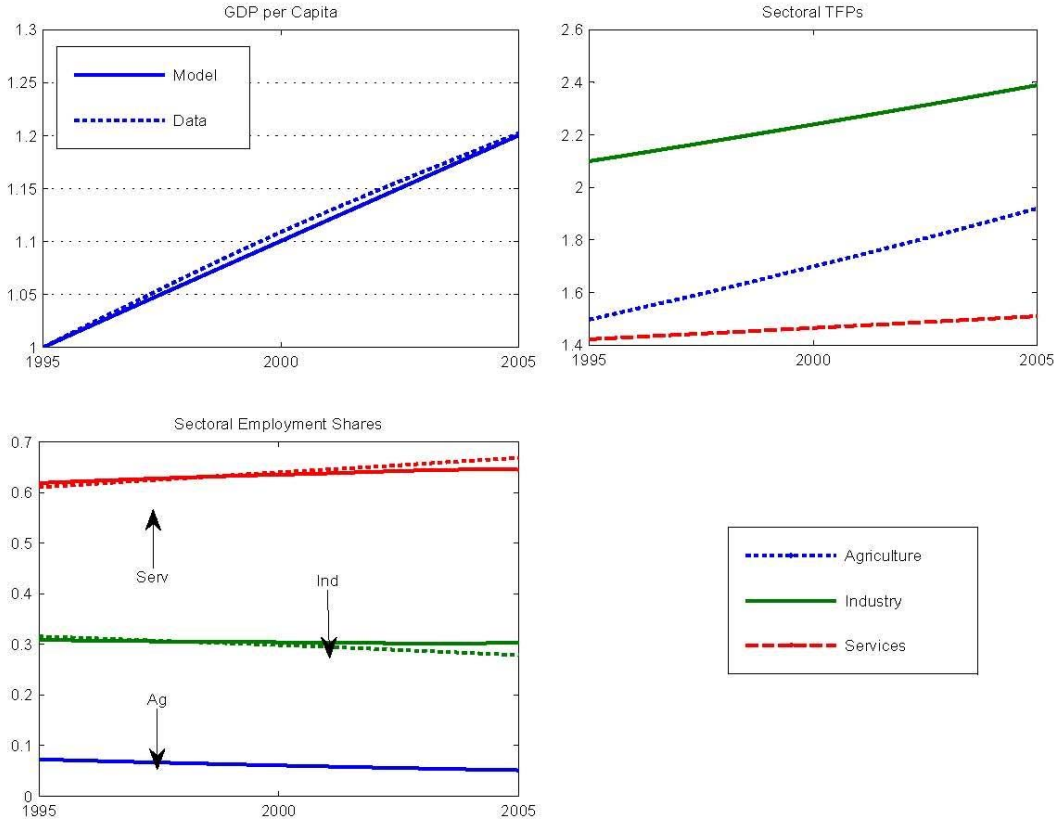

Figure 1: Austria

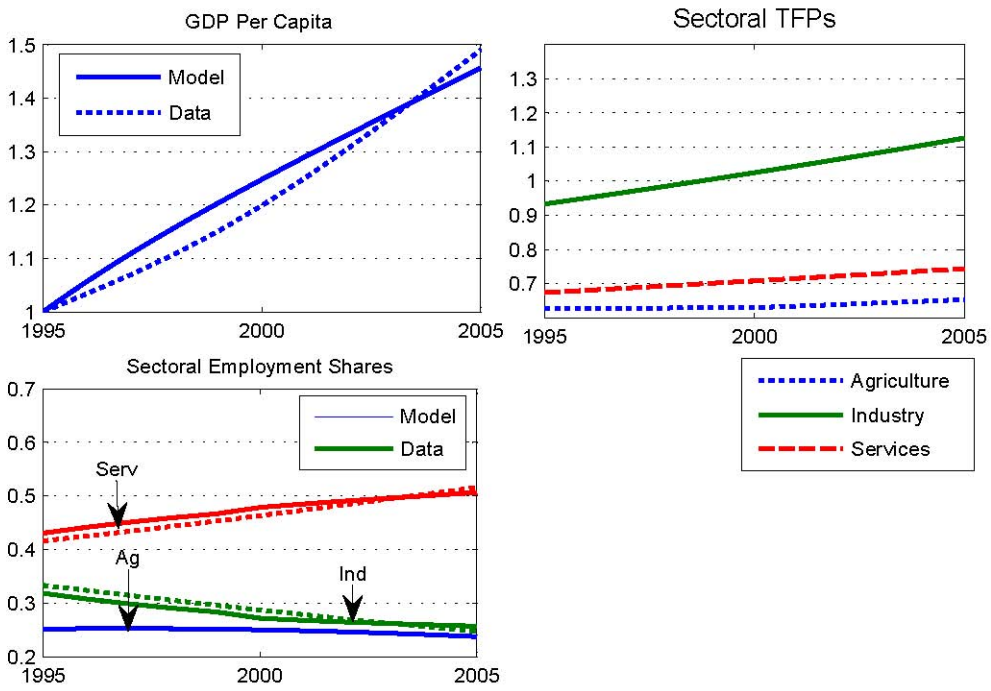

Figure 2: Bulgaria

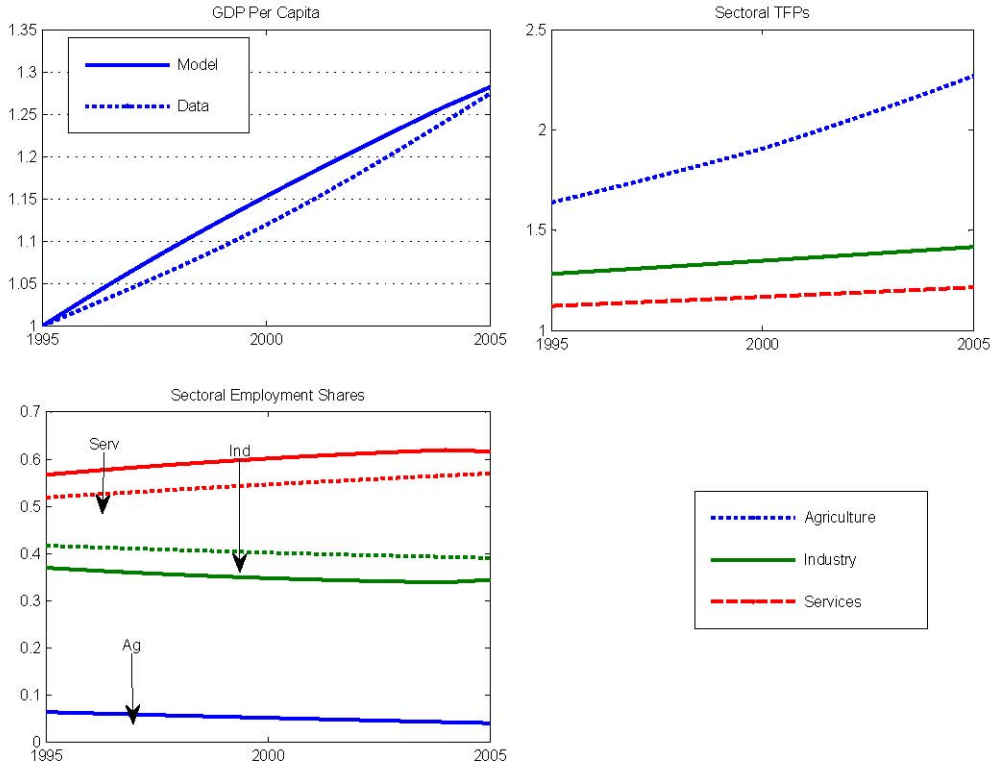

Figure 3: Czech Republic

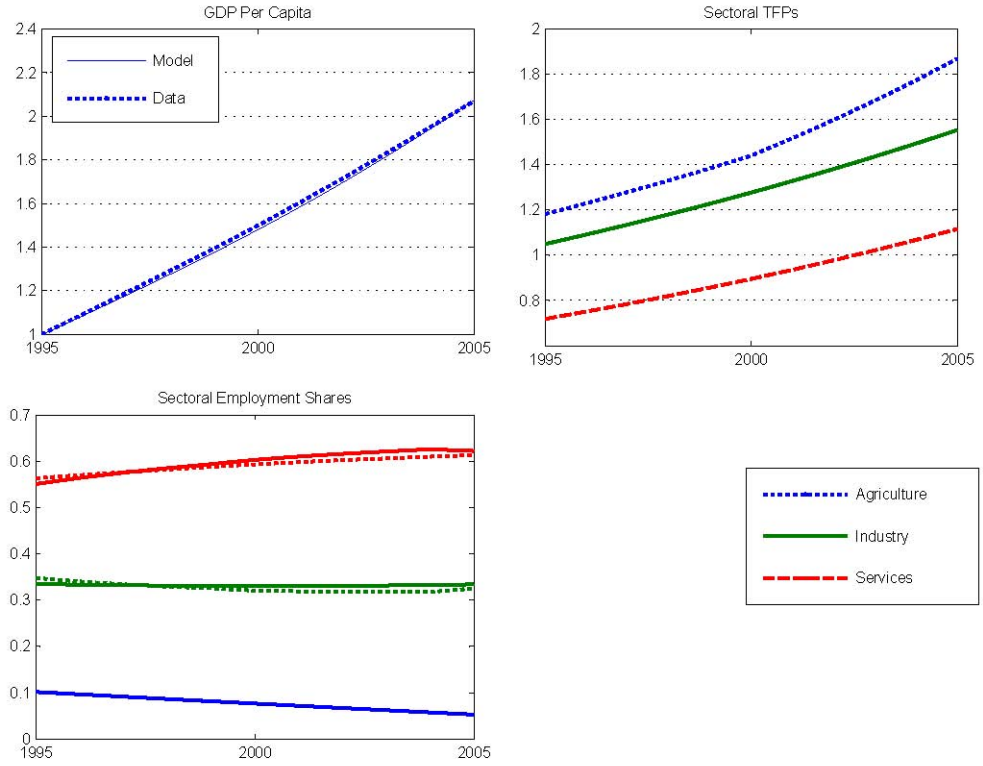

Figure 4: Estonia

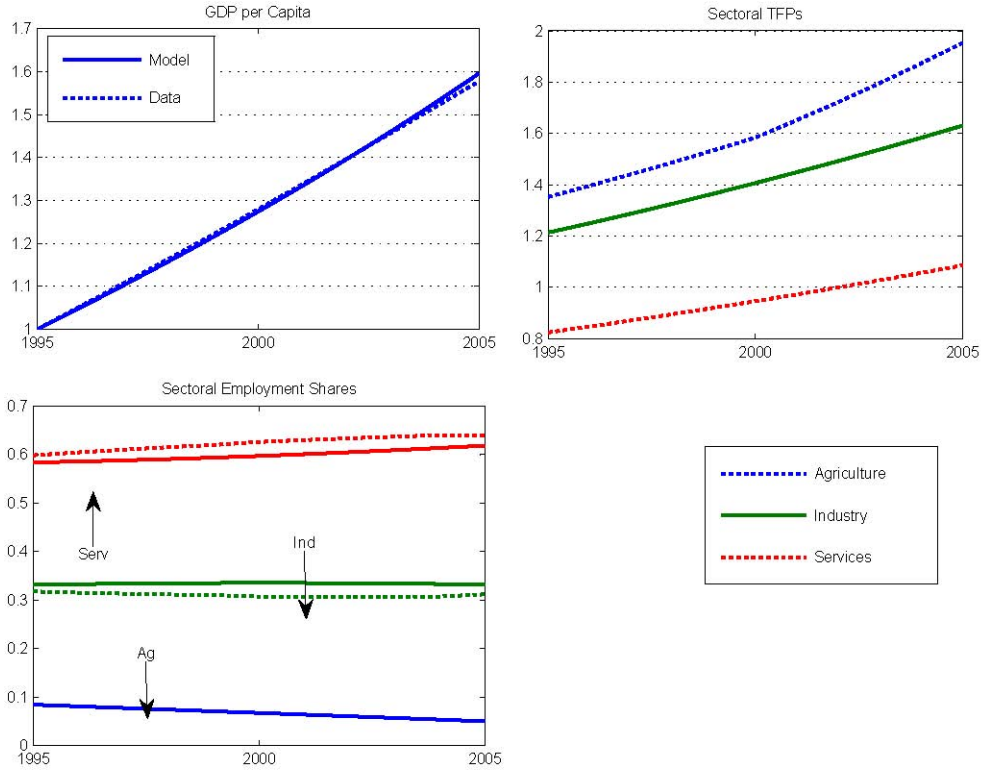

Figure 5: Hungary

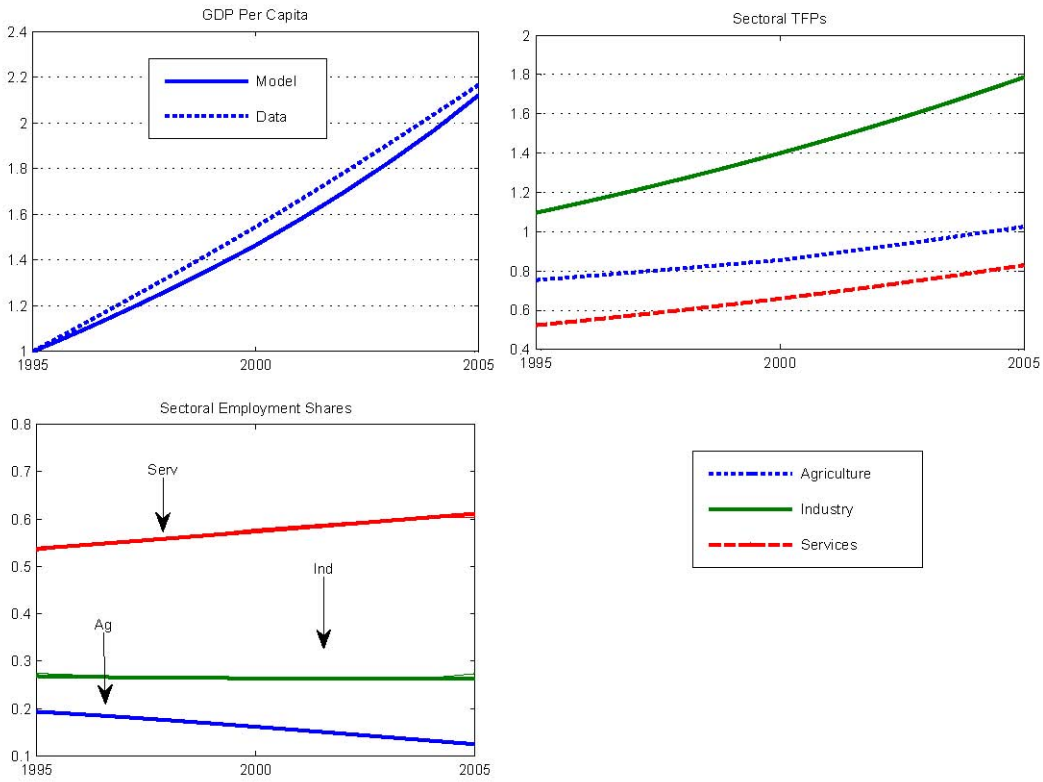

Figure 6: Latvia

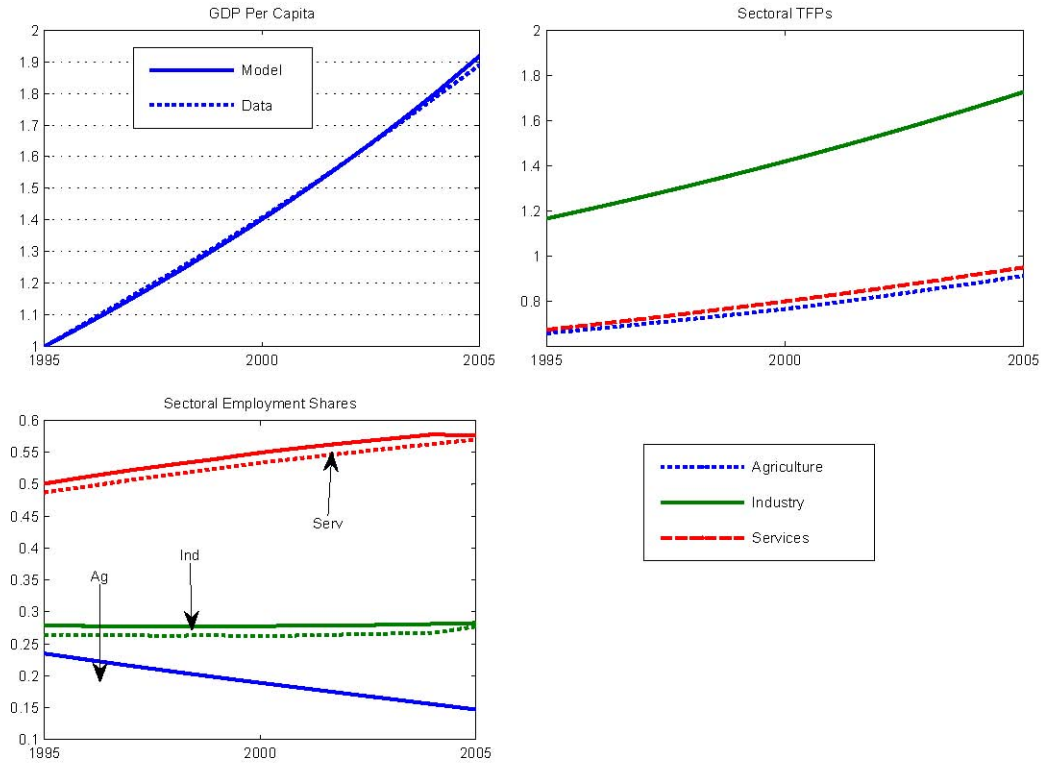

Figure 7: Lithuania

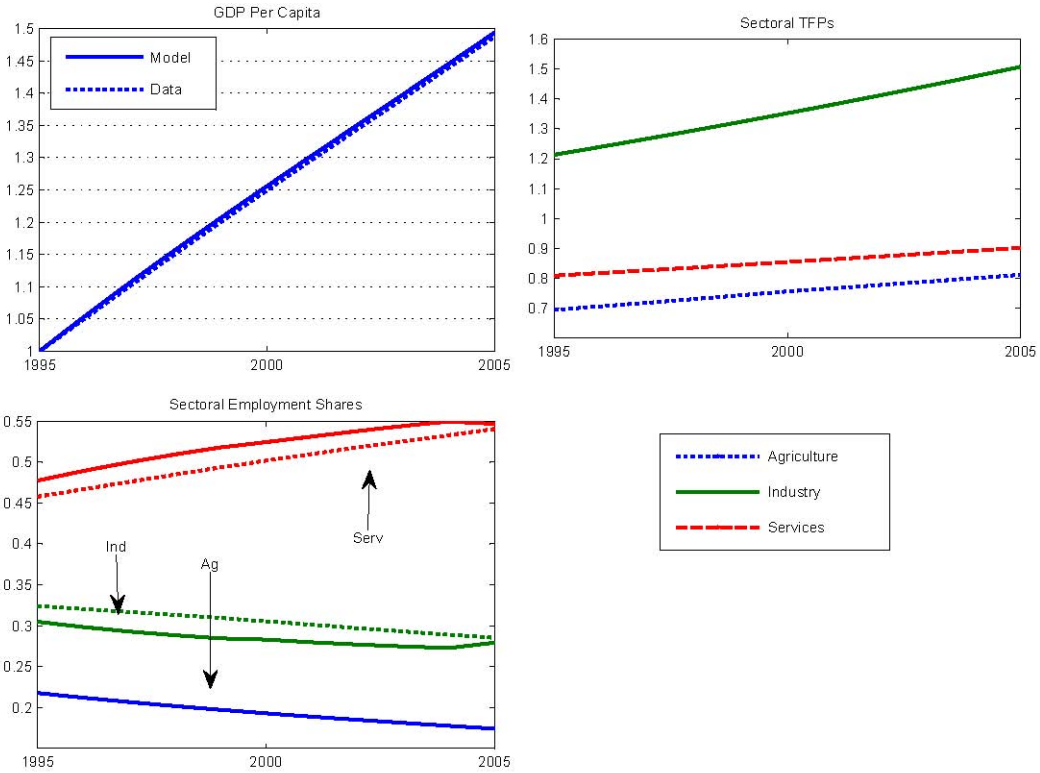

Figure 8: Poland

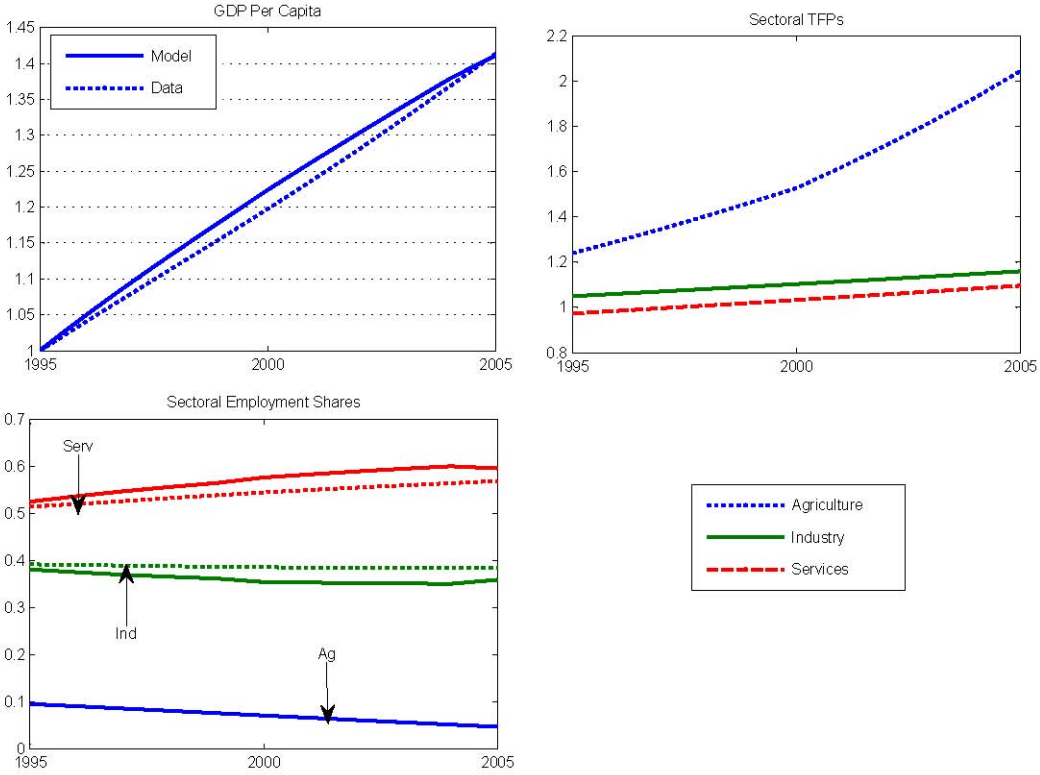

Figure 9: Slovak Republic

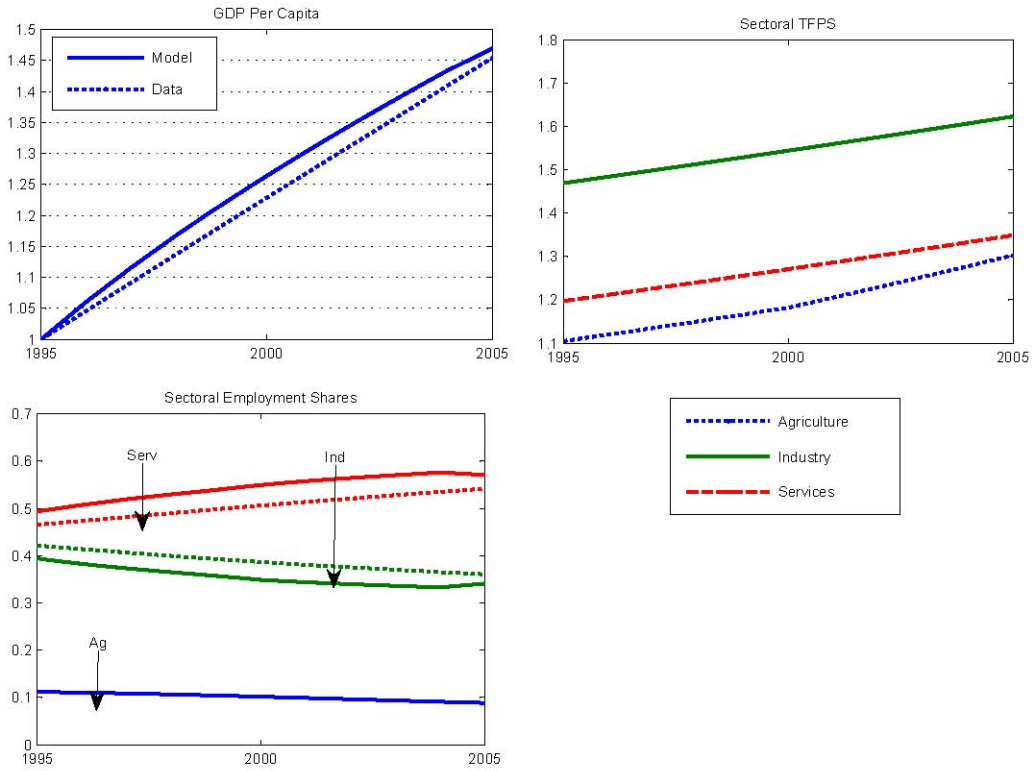

Figure 10: Slovenia

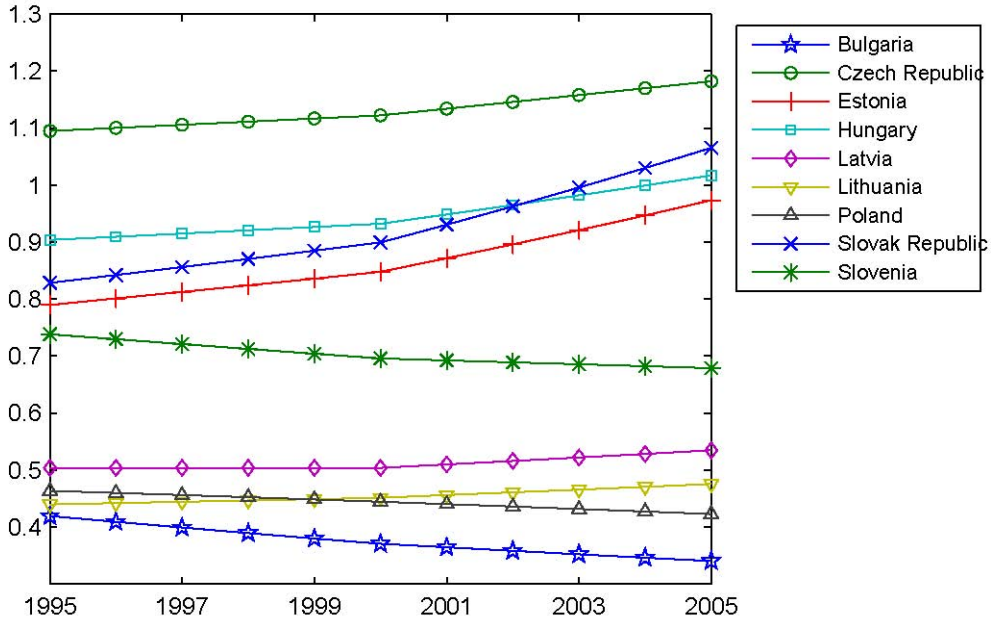

Figure 11: Agricultural TFP Relative to Austria

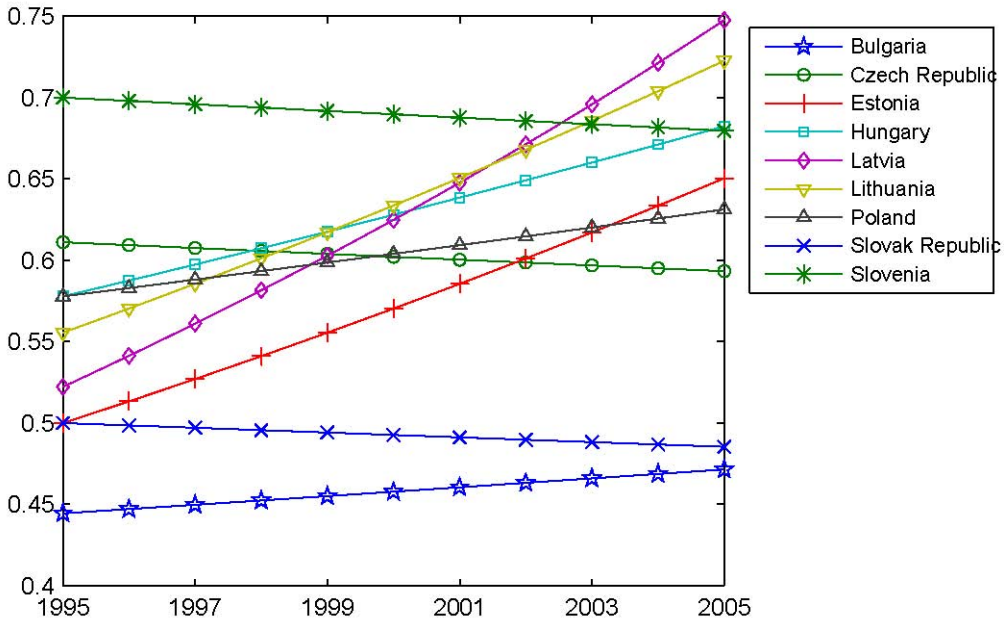

Figure 12: Industrial TFP Relative to Austria

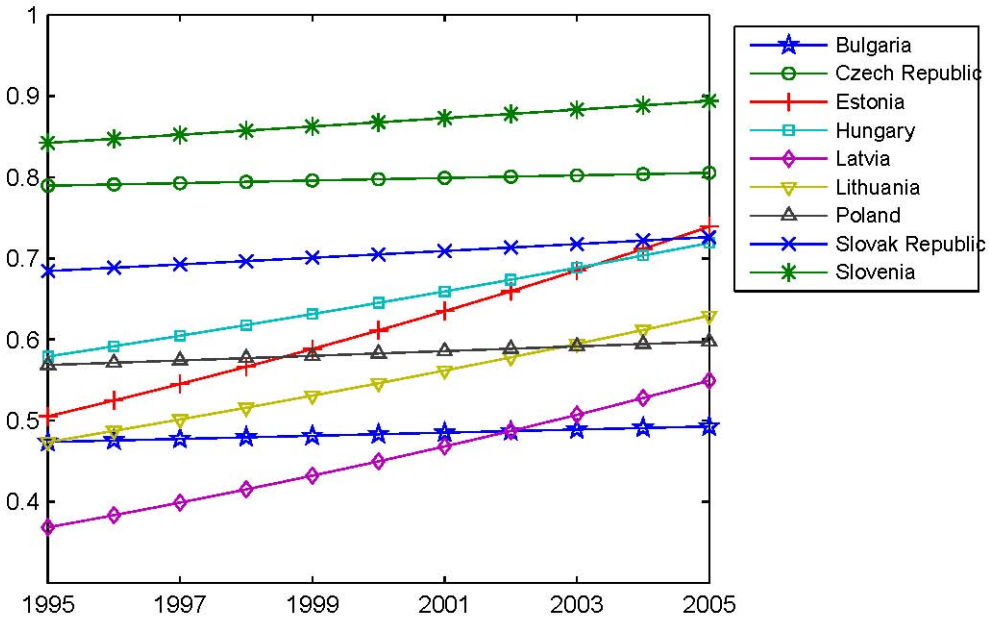

Figure 13: Service TFP Relative to Austria