Péter Harasztosi

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**Growth in Hungary 1994-2008: The role of capital, labour, productivity and reallocation***

(Növekedés Magyarországon 1994-2008: a tőke, a munka, a termelékenység és a reallokáció szerepe)

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# Contents

# Abstract

This paper relates firm level input changes and productivity to aggregate growth of the Hungarian economy for the period 1992 to 2008. The decomposition includes manufacturing, services, agriculture and construction. Results suggest that the role of firm productivity in growth was not stable over time. It played important role in early transition and in the pre-crisis period. Inputs show an initially positive then, after 2001, decreasing contribution to growth. At the same time input reallocation shows a decreasing trend in Hungary.

**JEL:** O47, D24, L25.
**Keywords:** growth decomposition, productivity, reallocation, firm level data.

# Összefoglalás

A tanulmány a vállalati szintű termelékenység és tényezőfelhasználás hozzájárulását vizsgálja az 1992 és 2008 közötti magyar gazdasági növekedéshez. A növekedésfelbontás eredményei azt mutatják, hogy a vállalati termelékenység szerepe nem egyenletes. Elsősorban a vizsgált időszak elején és a válság előtti években volt magas. A termelési tényezők szerepe a növekedésben kezdetben növekvő, 1999 óta pedig csökken. A termelési tényezők vállalatok közötti reallokációja Magyarországon időben csökkenő trendet mutat.

# 1 Introduction

Understanding the sources of growth is important. Monetary and fiscal policy rely on an accurate assessment of trends and underlying processes of growth. Quantifying the sources of growth reveals that a significant part of growth in modern economies is not caused by an increase in labour input or the stock of capital. It is achieved by transforming labour, capital, and materials more efficiently into output. The part of growth unexplained by changes in inputs is called aggregate productivity. Productivity plays an important role in the growth of countries. In most OECD countries, during the twenty years from 1985 to 2006, growth was driven primarily by productivity and capital.[1]

To measure the sources of growth, one can take two approaches: one can use (i) macro-level aggregates or (ii) firm-level information. As for the first, previous publications of the Central Bank of Hungary investigate the sources of potential GDP growth from a macroeconomic perspective (MNB 2008, 2009).[2] They find that the largest part of growth can be attributed to increases in the stock of capital and only a moderate part of the potential growth is attributed to labour and productivity. While the decomposition of growth from a macro perspective conveys concentrated information, it does not emphasize its constituting processes and dynamics. In contrast, a micro-level approach has the advantage of identifying, e.g., the part of aggregate productivity growth that is caused by more efficient production by the same firms, and the part caused by production capacities moving from less to more efficient firms (a process known as reallocation).

From the micro perspective, in a recent study, Kátay & Wolf (2008) have investigated factors of Hungarian growth and reallocation. They examined factors of growth in the manufacturing sector of Hungary in the 1994-2004 period. Decomposing growth of continuing firms[3] only, they found total factor productivity (TFP) to be on average the largest relative contributor to growth with a 36.5 percent share. They find that the role of productivity decreases in the second half of their sample period.[4] Other studies examine productivity only and do not relate it to growth. Brown & Earle (2008), examined reallocation effects for several transition economies, find that in the fast reformer Hungary the contribution of reallocation peaks in the 1992-95 period.[5] Kőrösi (2005) examines within sector labour reallocations, job creation and destruction in Hungary and points out that in 2001 favourable job creation tendencies stop. Very recently, Békés et al. (2011) exploring creative destruction amongst Hungarian manufacturers find significant reallocation gains until 2000.

This paper's main goal is to relate firm level input changes and productivity to aggregate growth of the Hungarian economy for the period 1992 to 2008. In particular, I extend the inquiry of Kátay & Wolf (2008) in several dimensions. First, I can extend the time dimension until 2008. This allows to evaluate the cyclicality of their finding about the decreasing productivity component. Second, the analysis covers four sectors: the focus is on two large sectors, manufacturing and non-financial services, but construction and agriculture are also analysed. Service sector, which over time became the largest part of the economy, provides important insights to growth analysis. Third, I also wish to revisit their aggregation problem. Evaluating individual input changes only, they find positive contribution of labour while the given sector contracts in size.[6] This calls for relating aggregate input dynamics also to growth. The present study seeks to answer the following

[1] Figure B (In appendix) collects contributions of production inputs to growth in a sample of countries.

[2] The Central Bank of Hungary uses models such as Benk et al. (2006) and Horváth et al. (2010) developed for forecasting and provides growth accounting for potential output.

[3] In changes from *t* to *t+1* only those firms are considered which are observed in both periods.

[4] Over the 1994-2004 average contributions to value added (VA) growth are found: 18.70 percent contribution by labour, 34.36 percent by capital, 10.34 percent by capacity utilisation and 36.52 percent by productivity.

[5] Brown & Earle (2008) examine Georgia, Hungary, Lithuania, Romania, Russia and Ukraine with a modified version of the decomposition used by Foster et al. (2001). Countries other than Hungary show larger and steadily increasing reallocation contributions to productivity growth.

[6] Kátay & Wolf (2008) explain this phenomenon by increasing labour cost that make firms react by gradually substituting capital for labour and by rationalizing production.

questions. What is the relative importance of aggregate productivity in growth and what is the relative imporance of labour and capital? What share of aggregate productivity growth can be explained by firms improving in efficiency and how important are reallocation gains?

To answer the questions above, I follow the methodology put forward by Petrin & Levinsohn (2005) (PL) in a recent work. They promote a decomposition that defines aggregate productivity growth from a macroeconomic perspective and which tries to relate aggregate growth to firm level dynamics. Besides trying to connect micro and macro level approaches the PL decomposition has several advantages. First, it embeds resource reallocation into an economy with frictions and imperfect competition. This is a key feature in reallocation, creative destruction driven endogenous growth models (Aghion & Howitt 1992). Second, when measured by the most frequently used techniques (Baily et al. 1992, Foster et al. 2001), reallocation effects often prove to be rather volatile and often produce negative values. However, frequent inefficient reallocations are puzzling in capitalist economies, where labour and capital should be put to their most productive use. The PL method produces less negative values and is significantly less volatile. This feature is demonstrated for the Chilean economy by Petrin & Levinsohn (2005) and Petrin et al. (2011) for the United States. As in Central Eastern-European countries reallocation is found relatively more important and volatile (Brown & Earle 2008) this feature of the method is attractive in the case of Hungary. Of course, understanding reallocations across economic agents with differing and technology comes at a cost: micro-based decompositions do not filter out business cycles and macroeconomic demand shocks. To compensate for this, attention will be paid throughout the paper to establish the connection between the results presented here and the stylised facts of the recent Hungarian growth experience gained from macro data.

The decomposition exercise for Hungary yields the following insights. Defining aggregate productivity growth over the corporate sector in Hungary enables to identify three periods. In the first and the last period inputs explain relatively less from GDP growth, while in the middle period inputs play a relatively more important role than aggregate productivity. The first period, from 1994 to 1997, exhibits growth through labour reallocation accompanied by downsizing of firms. The second period, from 1998 to 2001, is driven by investment, while the third period, from 2002 to 2007, results show that growth is lead by technology growth. For the last period the contribution of both factor accumulation and reallocation gains are significantly reduced.

The three periods defined by the relative share of input contribution also coincide with narratives about the stages of Hungarian transition. The first period covers the introduction and effects of the Bokros Package, a set of macroeconomic stabilization policies. Also this period sees the last larger wave of the privatisation process. The second period continues with the monetary framework of the stabilization package and encourages foreign investments. The third period starts with a shift in the monetary regime and a substantial increase in the minimum wage. Also in this period Hungary joins the European Union.

On average, I find that aggregate changes in capital have a higher impact on growth than changes in labour. In contrast, examining the input reallocation effect shows that the reallocation gains from labour are on average higher than corresponding gains from capital. Results on different sectors reveal considerable heterogeneity. For example, comparing sectoral dynamics of manufacturing and services show that, on average, aggregate changes in labour contribute significantly to service sectors but not to manufacturing. In contrast, in the manufacturing sectors I find the role of aggregate productivity more important.

Results of the present paper can be compared to previous macro approach decompositions by the Central Bank of Hungary (MNB 2008, 2009) only to limited extent. Micro decomposition include cyclical terms in the productivity. However, both micro and macro based approaches find the relative importance of capital higher than labour. Though the present study decomposes growth only in the corporate sector of the economy, I also find a post-1999 decreasing contribution of production inputs to growth. Findings are consistent with Kátay & Wolf (2008). Though their methodology of growth decomposition is somewhat different, results on the manufacturing sector are in line. For the period 1994-2004 observed by Kátay & Wolf (2008) this study also confirms the decreasing role of aggregate productivity in growth. However, the extended panel data used here implies that importance of aggregate productivity rebounds after 2002.

In this analysis I use the PL method to decompose aggregate productivity for continuing firms only. The main reason for this limitation in scope is that at the aggregate level entry and exit explains only small part of the GDP growth. The average GDP growth of the corporate sector is on average 5 percent. Entry and exit explains on average 0.35-0.38 percentage points of growth and their net contribution points to an average of 0.002 percentage points.[7] All in all, changes in dynamics through entry and exit are important at the industry level, but these issues are postponed for future research.

The remainder of this paper is structured as follows. Section 2 describes the methodology. Section 3 describes the data. Section 4 discusses the results from decomposition. Section 5.1 offers robustness checks on the dynamics of reallocation effects. Section 6 concludes.

[7] This is illustrated in Figure B in the Appendix. Another reason for limiting the scope comes from the construction of the dataset. Entry and exit could only be interpreted through being observed in the data by same identifier and not by actual economic entry and exit: data cleaning through Statistical Office firm registry allows to connect only some of the firms who changed identifier. Firms actually do not exit and enter when they are given a new identifier.

# 2 Methodology

There are several techniques available in the economic literature (see, e.g., Syverson (2011) or Gatto et al. (2011) for summaries) to decompose productivity and growth. The variety of techniques using firm level data allows researchers to choose the best technique to answer a research question. In the present case, the main goal is to relate firm level dynamics to aggregate productivity. These techniques define aggregate productivity mostly as the weighted sum of firm level productivity. However, as Biesebroeck (2008) points out, productivity measured at the aggregate level is not equal to productivity aggregated from firm level.[8] This creates a wedge between productivity calculated from firm level data and between one calculated from a macro perspective.

An approach that connects macro and micro level productivity is the growth decomposition methodology put forward by Petrin & Levinsohn (2005) (PL). Their framework consists of two main parts. The first part decomposes GDP growth into three components: contributions via aggregate changes in productivity, via aggregate changes in labour and capital. The second part gives a decomposition of the productivity term from the first stage. Let us see each of the parts in turn. In the first stage PL defines aggregate productivity growth (APG) from a macroeconomic, growth accounting perspective: the change in the final demand of the economy unexplained by change in aggregated expenditures on primary inputs. As the changes in final demand are unobserved in the data, its growth is approximated with the change in aggregate value added (VA).

$$APG = \sum_i \frac{VA_i}{\sum_i VA_i} d\ln VA_i - \sum_i \sum_k \frac{W_{ik}X_{ik}}{\sum_i VA_i} d\ln X_{ik} \quad (1)$$

The APG is calculated over all firms ($i$), and $k$ number of production factors (X). The first term of equation 1 is the aggregate value added growth, the second term is the aggregate change in the share of value added paid to input factors at price ($W$). In the case of labour $W$ is wage, for capital it is the user cost. That is, last two terms expresses changes in capital and labour compensation. Note that so far a firm level productivity index or productivity measure is not necessary.

The second stage is when the aggregate productivity growth is decomposed to aggregated changes at the firm level: technical efficiency (TE), reallocation (RE) gains from labour and capital and an aggregate fixed cost term (F).

$$APG = TE + RE_L + RE_K - F \quad (2)$$

While the Appendix contains a more precise derivation of the PL decomposition, let me briefly summarize each term in words.

Technical efficiency represents growth through changes in the productivity of individual firms. That is, how production improves given a set of inputs and production function. The TE term requires the calculation of a firm level productivity measure. Here, total factor productivity (TFP) is calculated in relation to a production function with two inputs capital and labour. In turn, technical efficiency is the value added share weighted sum of individual TFP changes.

[8] Biesebroeck (2008) shows that there is a scheme where the aggregation of TFP from the firm level equals analytically to the aggregate productivity. The problem with this scheme is however twofold. First, weights do not add up to one. Second, as weights depend on factors shares, the methodology makes aggregating TFP of firms from different sectors troublesome.

The reallocation terms reflect growth via changes in inputs. It assumes that fixed costs, market power, economic policy and other frictions and distortions prevent efficient allocation of resources. As a consequence, growth can be achieved through reallocation of inputs to firms which use them more efficiently. RE aggregates firm level changes in inputs. The contributing effect of an input change at a firm is valued by the gap between marginal product and the marginal cost of the respective input. For the gap to exist one has to assume away perfect competition: if marginal product and marginal cost are equal for all firms there is no room for allocative efficiency. The reallocation in the case of labour input is

$$RE_L = \sum_i D_i \left[ \epsilon_{iL} - \frac{w_i L_i}{VA_i} \right] \triangle ln L_i$$

where $\epsilon_{iL}$ is the elasticity of output with respect to labour, the labour coefficient of the production function of the firm. The term $\frac{w_i L_i}{VA_i}$ is the share of value added to cover labour costs and $D_i$ stands for value added share.

In this framework reallocation can make positive contribution to growth in two ways. Take labour reallocation for example. Hiring workers is growth enhancing until the employees marginal product is higher than their cost. But lay off may also yield positive growth if marginal cost is higher than production. Consequently, in the case of capital reallocation there are also four possibilities of for reallocation effects. Two positives and two negatives.

Theoretically, RE measures reallocation in the aggregate economy: the gap between marginal cost and product are determined at the firm level. Technically, one might not observe marginal cost and marginal product for all firms. The marginal product is approximated with the input coefficient obtained from productivity function at the sectoral level. At the same time, in the case of labour input, the share of value added paid in wages is viewed as the marginal cost of labour. Given that the production function coefficients are estimated for sectors, reallocation evaluates input changes relative to effective use in the industry: reallocation at sectoral level.

It is important to point out that reallocation in the PL definition is different from the Baily et al. (1992) (BHC) type definitions.[9] On the one hand, BHC looks at reallocation as shift of market share (or labour) to more productive firms. While PL restricts reallocation to that of inputs. On the other hand, the BHC type decomposition mainly through their level approach can more easily assess the effects of entry and exit.

The APG cannot be fully decomposed to TE and RE alone. There is a remaining term, F which is introduced as an aggregate capturing the effect of distortions and frictions. Theoretically, as derivations in the Appendix show, F represents the changes in the aggregate fixed cost. However, empirically it is also contains various effects: the variation originating from the growth of the exiting and entering firms, the statistical errors from aggregating deflated series. For the purposes of this paper, I will not give F economic interpretation but treat it as a technical term.

[9] Amongst them are Baily et al. (1992), Foster et al. (2001),Foster et al. (2002), Griliches & Regev (1995), Brown & Earle (2008).

# 3 Data

The firm level database used in this study is provided by the National Tax and Customs Office (NAV, formerly APEH). It contains balance-sheet information on double-entry book-keeping companies subject to corporate taxation. The data is available from 1992 to 2008.

While the data contain the universe of firms, the focus, for data quality purposes, is kept on four groups of sectors: Agriculture and Fishing, Manufacturing, Construction and Services. These sectors are responsible for the overwhelming majority of the corporate sector GDP and the 45-50 percent of the total Hungarian GDP. The remaining part is provided mainly by the government and household sectors as Table B in the Appendix illustrates it.

The industry groups and sectors are defined at the 2-digit level of TEÁOR'03 classification.[10] The 2-digit sectors included in the analysis are listed in Table B. The Table also shows the number of firms in each sector in the sample period. The number of firms varies substantially across sectors. For example, the *Beverage and Tobacco* sector has only 9 firms, while the *Publishing* sector has more than ten thousand. As data for small firms are often unreliable, firms with less than 5 employees are excluded to improve data quality.

The variables required for the productivity estimation and decomposition are constructed as follows:

The nominal capital stock is comprised of tangible and intangible assets, whose annual change provides nominal investment. To arrive at real investment 2 digit sectoral level investment deflators are calculated from the Hungarian Central Statistical Office (CSO) data. The real value of capital cannot be calculated with year-to-year deflators, as capital consists of several vintages. Hence, I use the perpetual inventory method (PIM), which builds up real capital from a series of investment. For continuing firms that enter prior to the start of the sample period 1992 is chosen as the base year with the argument that with the transition most capitals were re-evaluated to the market price. Consequently, observations from 1992 are excluded from the analysis. In the PIM construction, real capital is assumed to be governed by the following equation for each firm:

$$K_t = \begin{cases} (1-\delta)(K_{t-1}+I_t) & \text{for net real investment: } I_t > 0 \\ (1-\delta)K_{t-1}+I_t & \text{for net real disinvestment: } I_t < 0 \end{cases} \tag{3}$$

It assumes that real investment ($I$) takes place at the beginning of the year, while disinvestment takes place at the end of the year. That is, a positive investment also depreciates with rate $\delta$.

For labour input, the average annual employment of the firm is used. Value added is calculated as the turnover net of material costs. The real value added and materials are deflated to 1992 prices in HUF by respective sectoral deflators obtained from CSO.

For the Petrin & Levinsohn (2005) decomposition one needs factor prices. For labour, the tax reports provide payroll figures allowing to calculate average wage. For the price of capital user cost of capital is calculated for the firms. In calculating the user-cost for Hungarian firms I follow the method described in Kátay & Wolf (2004) with the equation:

[10] Hungarian TEÁOR system for industrial classification corresponds to NACE revision 1.

$$UC_{it} = \frac{\frac{p^I_{st}}{p_{st}}\left[\left(\frac{E_{it}}{B_{it}+E_{it}}\right)LD_t + \left(\frac{B_{it}}{B_{it}+E_{it}}\right)(1-u_{it})IR_t - \frac{\triangle p^I_{s,t+1}}{p^I_{s,t}} + (1-u_{it})\gamma_{it})\right]}{1-u_{it}}$$

where $B_{it}$ are liabilities, short and long term, $E_{it}$ - equity[11], $IR_t$ weighted average of bank lending rates (maturity longer than a year), $LD_t$ one year benchmark T-bill rate, $u_{it}$ is effective tax rate, $\gamma_{it}$ is effective depreciation rate, $p_{st}$ is industry (s) specific GDP deflator, $p^I_{st}$ industry ($s$) specific investment price index.

The firm level productivity is estimated with the method proposed by Levinsohn & Petrin (2003). The method tackles the bias arising from the idiosyncratic TFP changes foreseen by the firms (but not the researcher) and hence being correlated with input choices. The production function coefficients are estimated at 2 digit sectoral level. Sectors with few observations are merged with other industries in the same 1 digit classification. Therefore, a common production function is estimated for sectors 1, 2 and 3, for sectors 15 and 16, for sectors 22 and 23, for 36 and 37 and for sectors 60,61 and 62. *Office machinery* producing sector (30) is omitted from the data as the official deflators produce unrealistic real growth rates in the first half of the sample period.

[11] subscribed capital - subscribed capital unpaid + capital reserve + revaluation reserve + profit or loss for the year + accumulated profit reserve

# 4 Results

During the 1994-2008 period the Hungarian economy grew at an annual average rate of 3.2 percent. The highest and lowest growth rates were 0.7 and 4.9 percents and the rate of expansion was less in the years after 2000. The GDP growth is illustrated in Figure 1. In addition, it also contains the evolution of three other statistics. First, the GDP growth in the corporate sector, second, the GDP growth in the part of the corporate sector considered in this study. Both of them are official CSO statistics. Third, the graph also shows value-added growth calculated from the sample of firms in the data. Considering, that statistical offices use several data sources the fit seems satisfactory.[12] In the Appendix Figure 11 presents comparisons of official CSO statistics with growth figures calculated from the data at the sectoral level. They show rather good fit in the dynamic properties.

The results from the decomposition of real value added growth observed in the data are displayed in Figure 2. It represents all the decomposition terms separately, in each column their sum represents annual value added growth. Each consists of six components: the capital and labour contributions, and the four aggregate productivity terms, capital and labour reallocations, technical efficiency and the residual. The results show that the aggregate productivity is responsible for most part of growth. Its average share is 60 percent over the period. The second largest contributor is capital with an average share of 27 percent. On average the dynamics of aggregate productivity growth is driven by technical efficiency, the TFP growth of individual firms. It explains over 40 percent of aggregate productivity on average. The rest of the APG is reallocation and residual.[13] Underlying the majority of the TFP contribution on average, the importance of the factors varies considerably over time.

Based on the relative share and importance of the change in aggregate inputs the 1994-2008 interval can be divided into three different periods: 1994-1997, 1998-2001, 2002-2007.

- During the first period APG and changes in the capital input drives growth. The corporate sector witnessed growth significant decrease in labour. Unlike in the other two periods, the contribution of labour is negative.
- During the second period the aggregate change in capital has the highest contributing share to growth.
- In the third period aggregate productivity growth played the overwhelming role in value added growth.

The contribution of the factors averaged over above defined periods are displayed Figure 4.

The left panel of Figure 4 shows the decomposition of value added growth, the first stage of the decomposition. The growth in the first period is driven by aggregate productivity and exhibits negative contribution from the change in labour. The contraction of the corporate sector is connected to the post transition restructuring of many industries. The employment fell by 2-3 percent annually and as a consequence the aggregate wagebill in the corporate sector also decreased. On average, labour contributes a negative 2 percentage points to growth in this period, which is about -21 percent of the growth. The negative impact from the wages are, however, outweighed by both capital contribution and productivity. Aggregate productivity increased by over 7 percent on average in this period.

[12] The source of the discrepancy is manifold. One part of the difference comes from the fact that firms with less than 5 employees are dropped from the data. Second, to calculate real growth sectoral deflators were used. Adding up data previously deflated by chain indexes produces different dynamics in the aggregate. To overcome this, analysis of the decomposition results focuses more on the relative importance of the factors rather than on their size.

[13] The residual term in size is not negligibly small, on average it can be matched to reallocation effects. In fact, more than 60 percent of the residual can be explained by the growth variation caused by the entry and exit of firms. One of the residuals components.

**Figure 1**
**GDP growth in Hungary (1994-2008)**

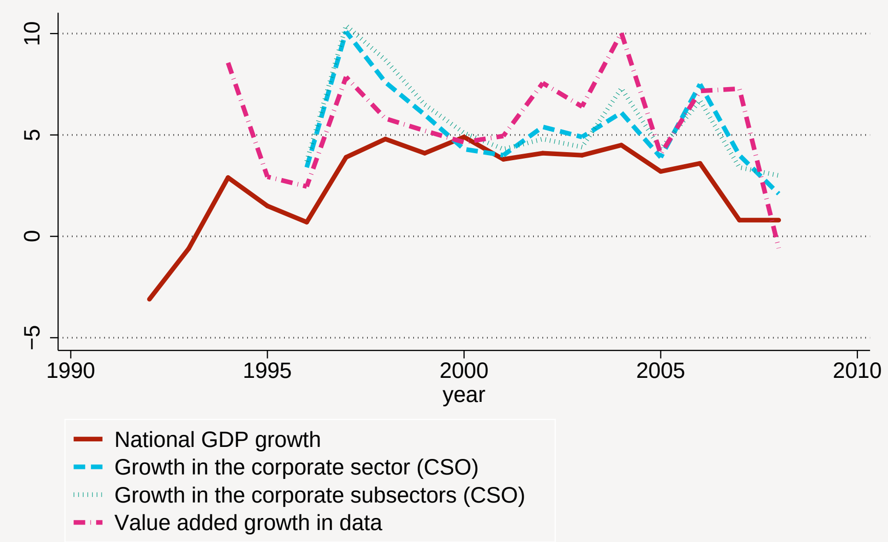
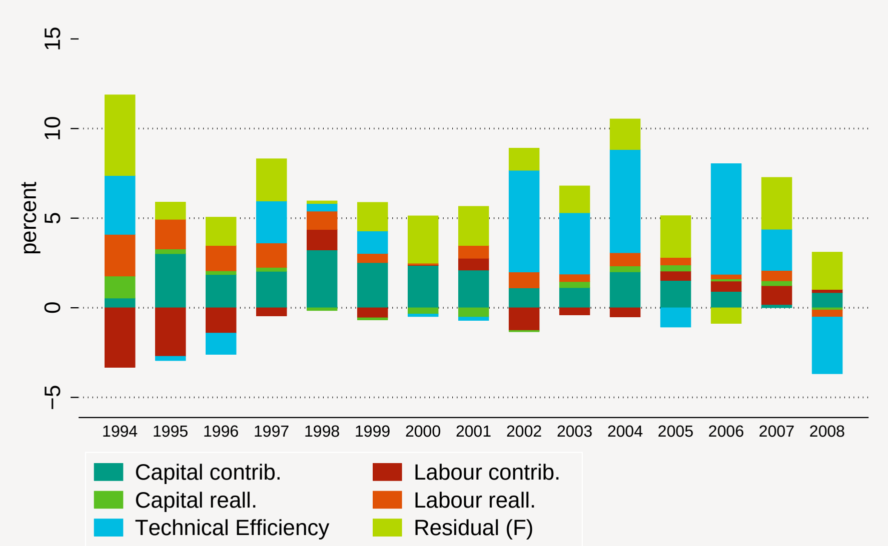



**Figure 2**
**Decomposition of value added growth in Hungary (1994-2008)**

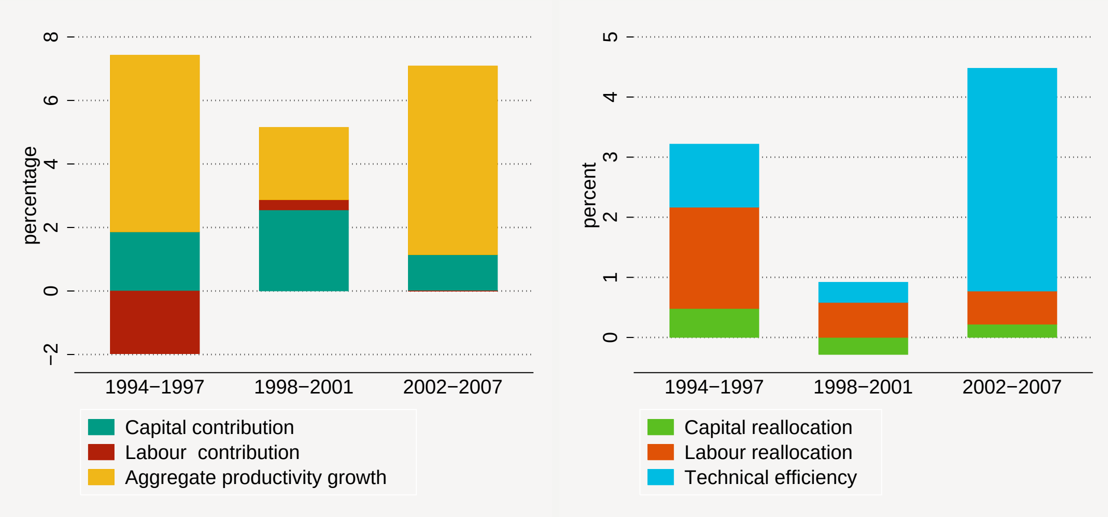



The Figure shows the results of the PL decomposition for the corporate sector sample including agriculture, manufacturing, construction and services.

The second period growth is mainly driven by the changes the aggregate capital. Capital, on average, explains 47 percent of growth. While APG explains 42 percent of growth, it contributes 1.5-2 percentage points to growth on average. The role of labour is minuscule in this period, but unlike in the first period its contribution is positive. The relative high role of capital contribution is explained by a wave of FDI that reached Hungary and that resulted in boosting investment serving as the engine of growth.

The post 2000 growth can be mainly contributed to aggregate productivity growth. It explains an overwhelming, 74 percent of growth in the last period. The share of capital contribution is 16 percent, less than half of the contribution in the

**Figure 3**
**Corporate sector growth and productivity decomposition: contribution averages**




(a) Value added growth

(b) APG

The Figure represents the two stages of the PL decomposition. Left panels shows the growth decomposition terms explain on average in time periods, 1994-1997, 1998-2001, 2002-2007. The right panel shows the decomposition terms explaining APG.

second period. The aggregate employment showed fluctuation in this period: aggregate labour contribution explains only 2 percentage points of growth on average.

The right panel of Figure 4 shows the aggregate productivity growth explained by reallocation or efficiency.[14]

In the first two periods labour-market-driven reallocations contribute the most to aggregate productivity growth. They explain 32 and 24 percent, respectively. However, the underlying economic processes are quite different. The positive reallocation in 1994-1997 is coupled with aggregate decrease in labour. That is, reallocation effect originates from lays off who have not been using labour efficiently. The 1998-2001 positive labour reallocation effect, on the other hand, is driven by the job creation effect. Part of the positive reallocation comes from firm openings via FDI into manufacturing sectors.

Post 2001 the aggregate productivity is driven by genuine productivity growth of individual firms. Technical efficiency explains about 50 percent of productivity growth, while the reallocation effects are small. They explain less than half of productivity growth as in the previous periods.

In the next subsections, I examine the role of the decomposition terms in growth in four industry groups: agriculture, manufacturing, construction and services. Sectoral decomposition allows to investigate the underlying economic processes in the corporate sector. In the case of manufacturing and services the decomposition identifies the contribution of 2 digit sectors within industry groups.

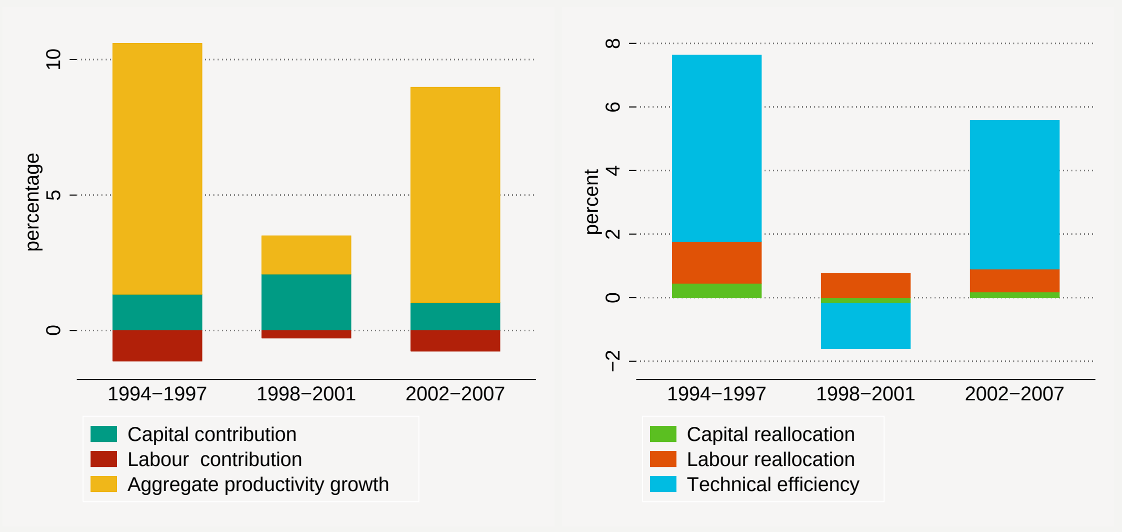
I start the sectoral analysis with the manufacturing sector. The main reason for this is that results can be compared to a previous decomposition analysis by Kátay & Wolf (2008). Though they use a slightly different technique, the database for the manufacturing sector is identical. In addition to being able to examine a longer period, this study provides the first growth decomposition for the other sectors in the Hungarian economy: services, agriculture, construction.

[14] The graphs do not show the share of the residual term (F) for easier readability

## 4.1 MANUFACTURING

The manufacturing sector represents approximately 20 percent of GDP. Employment in the sector increases until 2000 from 680 to 750 thousand, then decreases to 670 thousand in 2008. The largest part of manufacturing workers are employed in the machineries sector.[15] Its share in manufacturing is increasing steadily over the whole period. The only other expanding sector is that of *Metals*, while employment decreases in all the other sectors. In GDP terms, on average, the sector shows a real annual growth of five percent, with a rather volatile period before 2002.

**Figure 4**
**Manufacturing growth and productivity decomposition: average contribution shares**




(a) VA growth (b) APG

The Figure represents the two stages of the PL decomposition. Left panels shows the growth decomposition terms explain on average in time periods, 1994-1997, 1998-2001, 2002-2007. The right panel shows the decomposition terms explaining APG.

Figure 4 summarises the growth decomposition of the manufacturing sector. The representation is analogous to that of the corporate sector in Figure 4.

The right panel, which shows the first step of decomposition, implies that growth is primarily driven by aggregate productivity. In the first and in the last period, APG explains about 70 percent of GDP growth in the manufacturing sector. Its share shows a decreasing tendency in the first half of the sample period. In this period growth was the lowest on average in manufacturing. After 2002, manufacturing grows on average with a higher rate, with that, the share of aggregate productivity in growth rises.

With respect to APG the aggregate changes in the inputs play a smaller, but not insignificant role. Aggregate changes in labour, in all periods, imply a negative average contribution to growth. This negative contribution, however, they explain less than 10 percent of GDP growth. Negativity can be attributed partly to the employment outflow from the sector, especially in the 2000-2006 period. As for the capital , its contribution is higher in absolute terms than that of labour and it is generally positive. Its role is generally decreasing role of capital in manufacturing. However, there was a notable increase in the real capital stock in the 2003-2005 period. In this period, change in capital explained 45 percent of growth on average. More than the other two components did. This result suggests that the most part of the increased capital activity detected in the case of the whole corporate sector comes from manufacturing activity.

The decomposition of APG growth in manufacturing is portrayed on the panel b) of Figure 4. It leaves us with two lessons. First, the dynamics of aggregate productivity is generally determined by the efficiency of individual firms. Second, the contribution of reallocation effects is decreasing over time and they are fueled by labour. As for the first, technical

[15] TEÁOR'03 sectors 30-35

efficiency, when positive, explains more than 60 percent of aggregate productivity. In the 1998-2001 period, the average individual efficiency declines. This results that the aggregate productivity has on average the smallest contribution to growth in this period. As for the second, the contribution of the capital reallocations is rather volatile and compared to labour reallocation has a small scale. The labour reallocation effect, with the exception of the years 1999 and 2002, is always positive. As the employment is falling after 2000, this implies a within sector redistribution of workforce towards firms that use labour more efficiently.

Above observations can be linked to dynamics of various sectors within manufacturing. To do that I carry out the decomposition at sectoral level. For manufacturing includes 22 two-digit industries, I combine sectors into 8 groups to ensure easier tractability.[16] The results for each decomposition term using the 8 groups are displayed in the Appendix. Specifically, I seek answer to the following patterns using sectoral data: (1) the increase in investments in the second period, (2) the negative contribution of labour, (3) evolution of individual productivity growth and (4) decreasing reallocations. In the following paragraphs I will attend to these phenomena.

1. There is a hike in the investments of the manufacturing sector in the second period. Hungary witnesses a new wave of FDI in this period, which mainly targets already existing affiliates of large multinationals. Many of the firms already set in the Hungarian market wish to expand and or change the profile of production in this period.[17] Data suggests considerable capital growth in the Motor Vehicle industry and in the Electrical Machinery sector.

2. The manufacturing sector shows two waves of job destruction. One in the first and one in the last period. The first is due to the general contraction of the *Food and Tobacco* industry. Employment in this industry decreased by 30 percent over the examined period. The collapse of the *Textile* sector is responsible for the second shock. Sectoral employment decreased by an annual 11-13 percent in the third period. By the end of the sample period the sector becomes about half of its original size.[18] While the two waves of destruction determine the aggregate dynamics of the sectors there are several sectors where employment increased. In the Machinery sector *Radio and Television* manufacturing was able to double its size from 1994 to 2008. In the last period, *Metal Products* industry sector also created new jobs.[19]

3. The aggregate productivity for the manufacturing sector is on average driven by individual productivity growth of continuing firms. However, in the 1998-2001 period, one finds the importance of APG to drop and technical efficiency to decrease. This decrease was due to the poor performance of firms in the Chemical sector: the *Coke and petroleum* and the *Pharmaceutical* industry. Both sectors were heavily affected by the 1998 Russian economic crisis, the petroleum industry through oil imports and *Pharmaceuticals* via the collapse of export market.[20]

4. The contribution of reallocation to growth diminishes over time. Input reallocation effect seems to work mainly trough labour as the reallocation of capital is minuscule. The share of labour reallocation drops from an average 20 percent in the first period to a 10 percent in the last. The positive labour gap is mainly driven by the sectors of machinery in all periods. The other industries also show positive reallocation effects, though these relatively small. However, there are temporary hikes in labour reallocations. In the first period, *Food* manufacturing and the *Wood, Paper* sector show high reallocation gains. In the last period, *Textile* manufacturing shows higher positive reallocation.

[16] To facilitate any comparison with Kátay & Wolf (2008) I use the same grouping they did. The list of the groups (with 2-digit sectors included in the brackets) are the following: Food and Tobacco (15-16), Textiles (17-19), Wood, Paper and Printing (20-22), Chemical industry (23-25), Other non-metallic products (26), Metal Products (27-28), Machinery (29-35), Other manufacturing (36-37)

[17] From 1997 to 1998 AUDI makes investments to switch from engine production to assemble sportcars. On the other hand, from 1999 to 2001 the other big motor vehicle manufacturer, GM, stops producing cars for the Hungarian market and starts producing engines only for the international market. Flextronics, for example, invested in new production sites and bought up factories.

[18] There are several possible reasons for the contraction of the sector: one explanation can be the doubling of the minimum wage in 2001-2002 in Hungary. The share of minimum wage earners was the highest in the textile industry within manufacturing, hence these firms might have severed losses both in profitability and international competitiveness. See, e.g., Kertesi & Köllő (2003) for a detailed analysis on the effect of wage increase.

[19] Most of the employment growth in the sector is due to the privatisation and overhauling of the iron refinery in Dunaújváros. In the Radio and Television manufacturing, the last period sees new factory openings and job creation by the largest firms, e.g., at Nokia and at Samsung.

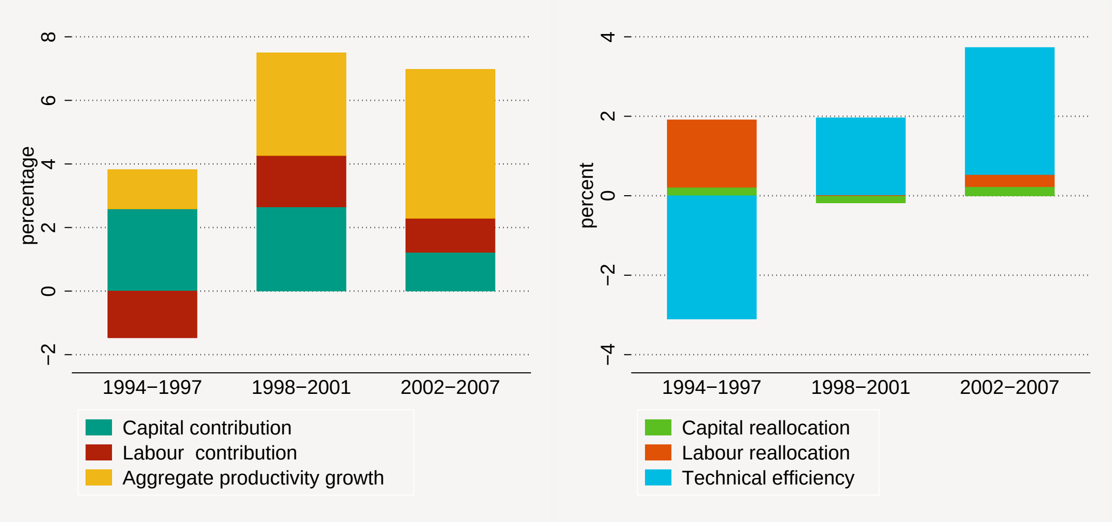
[20] Prior to the crisis Russia was the prime buyer of Hungarian pharmaceutical exports, with 11-13 percent share in the total export if the sector. The diminished purchasing power of Russian buyers urged manufacturers to enter other markets as well. By 2003, Russian exports' share halved, instead, U.K. and the U.S. became new top trade partners, while the significance of other nearby markets such as Italy or Poland remained.

Note, that positive aggregate labour reallocation is achieved in a mainly contracting sector. This is a result of two effects. First, a within manufacturing restructuring of employment from the low value added producing to high value added activities. For example from *Textiles* to *Machinery*. Second, the fact that labour reallocation effects are mostly non-negative, growth is achieved through the exit or contraction of the less profitable firms. More precisely, where the wage share in value added was to high with respect to the sector. This is true for the *Textile* and *Food* sectors, being responsible for the most part of the lay-offs. But it is also true for the chemical industry in the second period, which endured severe losses, decrease in profitability. The industry responded by cuts in wages and employment, a decrease in aggregate labour contribution. Still, the chemical industry showed positive reallocation effects.

## 4.2 SERVICES

The service sector generates an ever increasing share of the Hungarian GDP. Its contribution grew from 17 percent in 1994 to 28 percent in 2008. With this, it gradually took the leading role from manufacturing. Over the sample period the size of the employment rose from just over sixty thousand to nearly a million. All sectors show net job creation over the 1994-2008 horizon except for *Transport* and *Post and Telecommunication* where employment decreased by approximately 25 percent each. The only exception from a linear employment dynamic is the Retail sector where employment decreased up to 1997, then increased rapidly. Evolution of *Post and Telecommunication* and that of the retail sector define the labour dynamics of the service sector.

**Figure 5**
**Service sector growth and productivity decomposition: average contribution shares**




(a) VA growth (b) APG

The Figure represents the two stages of the PL decomposition. Left panels shows the growth decomposition terms explain on average in time periods, 1994-1997, 1998-2001, 2002-2007. The right panel shows the decomposition terms explaining APG.

Due to the intense dynamics in employment and sector size changes in the aggregate inputs contribute to growth considerably. This is illustrated in the left panel of Figure 5. It shows the contributions of the decomposition terms to growth, averaged over the three subperiods. In the first and the second period aggregate changes in capital explain the highest share from growth on average, 37 and 40 percent respectively. It contributes on average more than 2 percentage points to GDP growth. In the third period, capital's share drops to 16 percent, adds to GDP growth on average 1 percentage point. Change in aggregate labour shows an increasing contribution. In the first period, the change in aggregate labour contributes negatively, dampening growth by approximately 1.7 percentage points on average. In the next two periods, however it explains about one fifth of value added growth, between 1.5-2 percentage points annually. The role of aggregate productivity is ever increasing in services. In the first period, it explains only 25 percent of growth, while in the 2002-2007 period its share in growth is 56 percent. In the last period, APG becomes the foremost engine of growth. Data shows that out of the average 6-6.5 percentage point services growth, APG is responsible for 4-4.5 percentage points.

The core determinant of aggregate productivity in the service sector is technical efficiency. This is illustrated in the right panel of Figure 5. In the first period TE shows negative contribution of 40 percent to APG and dampens growth on average by 2.5-3 percentage points on average. In later periods, it explains aggregate productivity almost entirely and enhances growth by 2-4 percentage points.

The role of reallocation in services is limited to the first period. In the later periods its role is minuscule. From 1994-1997, labour reallocation effects explain 21 percent of APG and on average it adds 2 percentage points to the growth rate.

As in the case of manufacturing, data allows me to link dynamics of the whole sector to that of the contributing industries. For the service sector sample includes 14 two-digit industries, I combine sectors into 4 groups to ensure easier tractability.[21] The results of the decompositions are displayed in the Appendix. Specifically, I seek answers to the following patterns using sectoral data: (1) The high share of capital contribution, (2) labour's negative contribution in the first period, (3) first period labour reallocations.

1. The high contribution share of capital in the first two period is primarily driven by the investments made by *Post and Telecommunications*. There are two key motors of growth: the privatisation in the landline telephone sector and the emergence of the mobile telecommunications technology.[22] In addition, high capital growth can also be attributed to the growth of *Wholesale* sector.
2. The most striking feature of the service sector growth is the shift from negative to positive labour contribution in the first two periods. The labour growth dynamics in the first period is defined by the restructuring of the *Retail* sector and the *Transport* sector. In both sectors the bulk of the negative effect is due to the gradual downsizing of surviving pre-transition firms. Nationwide retail chains that in socialism specialized in various household needs, e.g., furniture, kitchenware or clothing laid off their employees and eventually left the market. Their place was taken over mostly by multinational chains. In the case of the transport sector the downsizing primarily affects public transportation, railway and regional bus service sectors.[23]
3. Reallocations only play significant and positive role in the first period. Most of the reallocation takes place in the *Wholesale, Retail and Transportation* industries. In the case of the two latter industries the reallocation gain is achieved primarily through decrease in the share of value added paid to labour.

## 4.3 AGRICULTURE AND FISHING

The agricultural industries represent a small and gradually diminishing share of the Hungarian production. Its share in GDP fell from a 2.9 percent in 1995 to 1.7 percent by 2008. The labour force more than halved from the early 1990's until 2008, while the number of firms stayed approximately constant. The growth of the sector is highly volatile with two large jumps in the production in 2004 and 2008, characterised with double digit growth rates. See panel (a) of Figure 16.

In the agriculture and fishing sector the volatility of growth is captured by the aggregate productivity growth. Calculating the aggregate productivity growth reveals the changes in aggregate inputs over the period. The labour contribution is negative in every year in line with the sector-wide decrease in employment. On average the employment outflow induced labour decrease takes away 4 percentage points from agricultural growth. The capital contribution change is positive, except for the year 2000, as a result of a series of real investments in the sector in the period 2001-2004. From 2000

[21] Wholesale and retail (50-52), Hotels and Restaurants (55), Transport, Storage and Communications (60-64), Real estate, Renting and Business Activities (70-74)

[22] The Hungarian telecommunications giant, Matáv Rt., was privatised in 1993 and was introduced on the stock exchange in 1997. The first GSM mobile service in Hungary was launched in 1994 by Pannon GSM. The dynamic growth of the sector ensures full reception coverage of Hungary by 1996.

[23] The Hungarian state railway company, MÁV, has decreased the number of workers by more than 20 percent in the first period. This employment reduction alone responsible for 70 percent of the employment decrease in the Transportation sector.

on, aggregate capital contributes 2.5-3 percent to the growth of the sector on average. Overwhelming part of aggregate productivity growth in the agricultural sector is genuine TFP growth when looked at annually. However, on average, labour reallocation effects play a significant positive role in growth.

## 4.4 CONSTRUCTION

The construction sector is responsible for 2.5-3 percent of the Hungarian GDP. The sector exhibits boom and bust periods lagging the market demand considerably. The sector demonstrates strong growth in the second period, from 1998 to 2001, following a period of negative growth and job destruction. Decomposition, shown in the Appendix, suggest that it is the second period where most of the investments occurred in the construction sector.

The last period shows large variance in growth: alternating periods of short booms and busts. Aggregate labour changes in this period are mostly counter-cyclical. That is, in boom aggregate labour increases, in bust it decreases. This points to the sluggishness of adjustments and limited flexibility of the sector.

In the construction sector the role of reallocation is relatively high. In the first period, the aggregate productivity growth was driven by labour reallocation. Given, that the first period the aggregate employment and wages fall in the sector positive reallocation can be contributed to the downsizing and closing down of the least efficient firms. In the last two periods, the role of reallocations is smaller, the APG is almost solely determined by technical efficiency changes. Though, APG has alternating signs in the last two period, reallocations are always positive. This implies that the sector, over time, became more homogenous and firms choose labour and capital input more efficiently.

# 5 Extensions

## 5.1 ROBUSTNESS OF REALLOCATION RESULTS

This section investigates several robustness and sensitivity issues regarding the reallocation gains estimated. Unlike the calculation of aggregate productivity defining reallocation gains and technical efficiency depends on the estimation of production functions. Throughout the calculation one assumes that a technology is the same across firms within a more or less narrowly defined sector, over a certain period of time. To see to what extent these assumptions are acceptable, this section looks into the following questions. How much do results depend on the choice of production function coefficient estimation methods? Do firms within the same sector have the access to the same production technology? Do results depend on the length of the time period for which production functions are estimated? In the upcoming section I look into these issues separately.

1. *The method of production function estimation might matter*. Petrin & Levinsohn (2005) and Petrin et al. (2011) show that choice of production function estimation technique may influence reallocation results. This comes from the fact that the sign and size of reallocation measures depend critically on the production function parameters. The positive reallocation effect of job destruction, for example, is smaller if labour coefficient is overestimated.

   Obtaining production function coefficients is not straightforward. It is known that OLS estimation of a production function yields biased coefficients.[24] The biased estimation is due to the unobserved firm level heterogeneity that may be correlated with productivity. More productive firms may target larger markets, hire more and better workers and invest more in machinery. In addition, the annual data frequency may also cause problems. A firm may observe a good or bad shock early in the year and hence adjust hire of fire workers. In theory, the production function estimation by Levinsohn & Petrin (2003) can address endogeneity successfully. Castellani & Giovannetti (2010) argue, that the Levinsohn & Petrin (2003) may overestimate productivity of large firms and as a consequence resource allocation to large firms may appear relatively more important. Békés et al. (2011) argue the same and point to its relevance in Hungarian data. Indeed, in OLS estimates for the sectors used in this paper show significantly higher returns to scale.

   To assess the effects of productivity function choice on technological efficiency and reallocation results I recalculate APG decomposition with alternate specifications: OLS, Firm fixed effects (FE) and the an augmented version of Levinsohn-Petrin Wooldridge (2009) (WLP). The reallocation results for both inputs and technological efficiency are displayed in Figure 17 (Appendix) for the manufacturing and the service sectors.

   Results imply, that alternative production function estimates provide different allocation levels, while dynamics appear more preserved. On average, OLS regressions give the highest reallocation effects and the Wooldridge (2009) production functions provide the lowest values. Fixed effects estimation shows high labour and low capital reallocation effects. While, specification used in this paper takes the middle road. In contrast to the reallocation effects the dynamics and the level of technological efficiency growth is robust to estimating specifications.

2. *The production function might not be the same within sectors*. This concern may arise because some firms within the statistically defined sectors use different technology and consequently value labour or capital differently. For example, firms competing on international markets have larger scale requirements may choose to adopt a different technology. Also, firms of foreign ownership may have access to different, more up-to-date production technology. In Hungary most foreign owned firms trade, thus both arguments apply to them. In any case, assuming the same production function for all firm in one statistical sector may over or underestimate firms TFP. Furthermore, as the

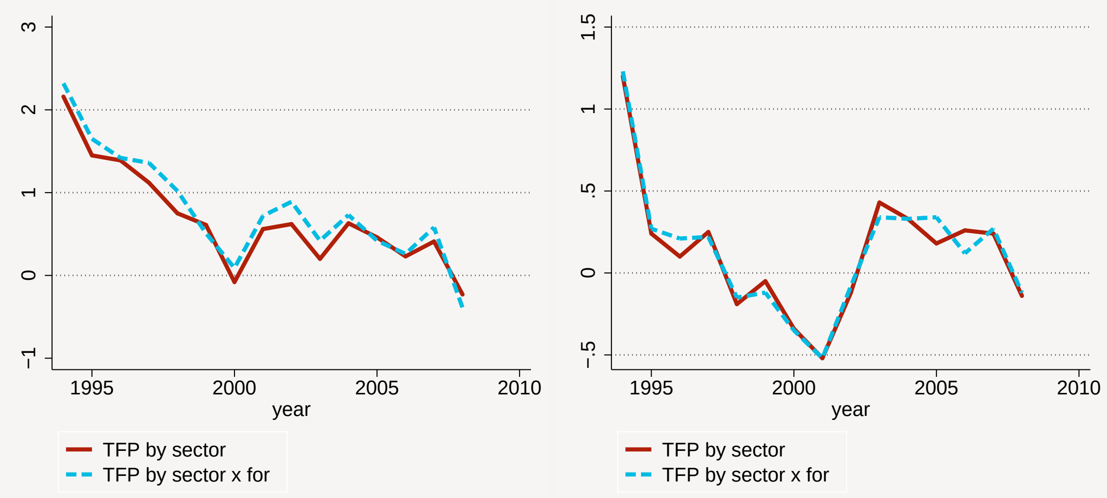
[24] See, e.g., Marschak & Andrews (1944) , Griliches & Mairesse (1995) for details.

production function coefficient would be different the PL decomposition method may evaluate factor changes in a firm as reallocation of different signs.

To see, if possible within sector production function heterogeneity causes changes to the inference I estimated production function coefficients for within industry subgroups. To form more homogenous groups I separated foreign owned and domestic firms.[25] Re-estimating production functions and individual TFP's allows for an alternate decomposition of APG. A comparison of the main reallocation results for the whole corporate sector and of those calculated from the ownership defined sectors is displayed in Fig. 6. The right panel compares labour reallocation contributions, while the left panel compares the same for capital.

Results imply that separating firms within a sector by ownership changes reallocation effects only slightly. The general inference about reallocation remains intact. The same inference can be drawn about the evolution of technical efficiency as well.

**Figure 6**
**Input reallocation: separate TFP for domestic and foreign firms**




(a) Labour reallocation (b) Capital reallocation

The figures compare reallocation gains calculated with two methods. The solid line is the baseline used in the paper, while the dotted line is calculated with separating foreign owned firms. Left panels shows labour, right panel shows capital reallocation.

3. *Production technology might not be the same over time within sector*. While this assumption is necessary to define productivity changes within a firm, might not hold for each of the sectors over the whole sample period. The intense reallocation effects in the early years of the sample and also the relative increase in capital investment activity might suggest that some sector adopted new technologies over time. In some sectors the capital and labor intensity of production can be quite different at the beginning and at the end of the period. Such a structural break would effect reallocation inference.

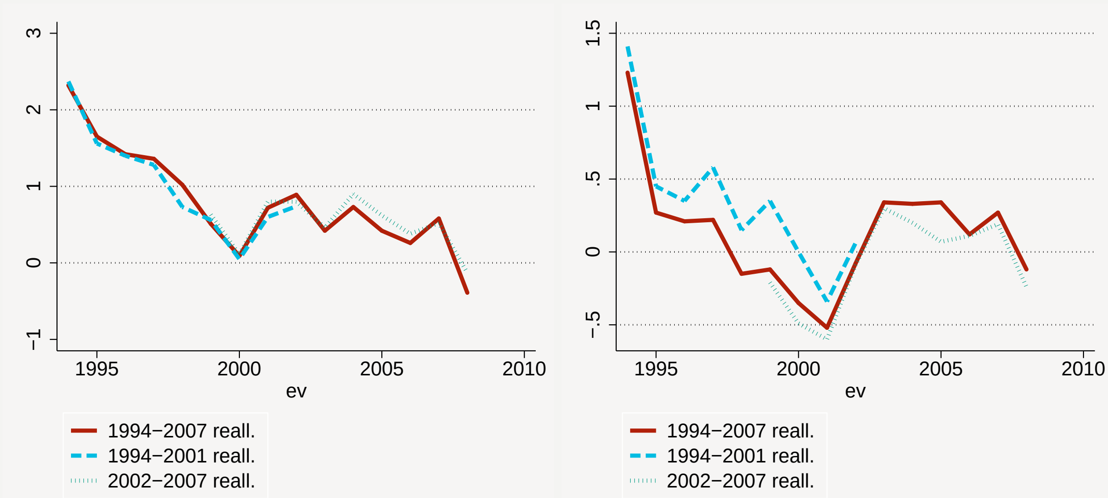
   To see the effect of a possible structural break in some sectors I re-estimated production functions for two overlapping subperiod. The first period is from 1994 to 2001, while the second period is from 1998 to 2007. Each of them contains two of the three periods of the main analysis. The re-estimated production functions allow for a recalculation of the decomposition of the APG for each of the two periods.

[25] To ensure suitably large sample size for estimation I merged some of the two-digit sectors before separating foreign and domestic firms. Namely, 26 and 27, 34 and 35, 63 and 64, 70 and 71, 72 and 73. I defined a firm to have foreign ownership if more than 50 % of its subscribed capital is foreign owned.

To see the effect of a possible shift in the production function of any of the sampled sectors I compare the new reallocation calculations to the main findings. Figure 7 compares input reallocation results calculated for the two subperiod with the decomposition carried out for the whole period. The left panel shows labour reallocation contributions, while the right panel compares growth contributed to capital reallocation calculated separately over the 3 time periods. In each case reallocation is calculated for the full corporate sector sample.

The two inputs allow to make slightly different inferences. In the case of labour the three reallocation series nearly coincide. That is, looking at separately at the end or the beginning of the period does yield a different inference than looking at the whole period. In the case of capital reallocation the fit of the three series is slightly less ideal. Looking at the 1994-2001 period only provides a slightly higher capital reallocation than what is arrived at from the whole sample.[26] The discrepancy implies bit higher capital reallocation in the first two period. Given that the capital reallocation gain very small this effect is negligible.[27] On the general, dynamics of the reallocation is intact. The 1998-2007 period shows no difference from the whole.

**Figure 7**
**Input reallocation: shorter period estimates 1994-2001 and 1998-2007**




(a) Labour reallocation (b) Capital reallocation

The figures compare reallocation gains calculated for three different periods separately. The solid line is the baseline used in the paper for the entire examined period. The dashed line is calculated for the 1994-2001 period, the dotted line is calculated for the 2002-2007 period. Left panels shows labour, right panel shows capital reallocation.

Results imply that there can be a structural break in the Hungarian economy in certain sectors. However, the possible breaks have only a moderate effect on the decomposition results. One reason is that capital reallocation, where possible production technology shifts can be detected, contributes little to growth. Another reason is that possible structural breaks in any sector are weighted against the sectors relative share in the value added of the national economy. This latter idea suggests that if one investigates sources of growth in individual sectors irrespective of their economic importance, the length of the period chosen from the Hungarian economy might alter inference significantly.

[26] Looking to the sources of the discrepancy reveals that two sectors, Electrical machinery (31) and Motor Vehicles (34), show considerable different capital coefficients when estimated from the 1994-2001 sample or when from the 1994-2008 one.

[27] Capital reallocation on average contributes 0.4 percentage point to growth in the 1994-1997 period, while -0,2 percentage point in the 1998-2001 period. When the production function is estimated for only these years the figures are 0.6 and 0.04 respectively.

## 5.2 POSITIVE AND NEGATIVE REALLOCATIONS

So far reallocation gains were evaluated at the aggregate level. However, reallocation gains or losses are determined at the level of the continuing firm. This, in turn, allows the precise identification of the sources of net gains. In this section I decompose labour reallocation into positive and negative contribution and see how much of the contribution is achieved from job creation and job destruction.

The construction of reallocation contribution allows categorize input flows as relatively good or relatively bad. This can be linked to one dimension of the creative destruction concept. Creative destruction advocates part of growth is achieved through the industry dynamics of resources flowing from least productive firms to the more productive ones. Least productive firms leave the market, and their resources are taken over by new entrants and more productive incumbents. The PL decomposition captures part of this effect across continuing firms.

**Figure 8**
**Labour reallocation components: Manufacturing and Services**


(a) Manufacturing

(b) Services

The figures decompose labour reallocation gains into four parts: positive and negative effects of hiring and firing policies. These are represented by the coloumns, while the solid line shows their net effect. Left panels shows manufacturing, right panel shows calculations for the services sector.

The reallocation gain is comprised of four elements. These are the positively or negatively valued hiring and firings as discussed in section 2. Figure 8 decomposes the labour reallocation findings in the case of two sector groups manufacturing (on the left) and services (on the right). In both cases I use the three period classification introduced with the main results and so results are within period averages. Each period holds four bars. The first two from the left collects negative contributions, bad job creation and bad downsizing. The next two collects labour policies with reallocation gains: good hiring and good downsizing. The net effect of reallocation is shown by the line.

There are two common trends that Figure 8 suggests. First, the largest part of reallocation is coming form good fire and bad hire. Second, over time decreasing trend in the net reallocation gain is driven by good fire. This latter finding implies, that especially in the early years of the sample a kind of creation destruction was in action.

Manufacturing and services in the aggregate show some dissimilarities as well. In the case of manufacturing the hiring policy seems neutral as negative and positive effects cancel. In the case of the service sector hiring policy in itself gives negative contribution. In both cases the gain is achieved though good firing policies. However, in the case of service sector a more effective downsizing is need for a positive reallocation gain.

# 6 Conclusions

This study examines the growth of the Hungarian corporate sector between 1994 and 2008. I used the decomposition framework developed by Petrin & Levinsohn (2005) to identify and to better understand sources of growth. I kept the focus on the relative importance of individual efficiency, input contributions and input reallocation. Results show how the relative importance of production inputs changes over time. I find that the input contribution is relatively more important in the early years of the examined period. Consequently, the later periods are mostly driven by changes in aggregate productivity. Comparing the relative importance of input factors reveal that capital always has a higher contribution than labour.

Regarding the components of aggregate productivity the following patterns emerges: reallocation contributions to aggregate productivity show a decreasing trend. Economy seems to exhaust possible reallocation gains. The size of reallocation gains are determined more by labour and less by capital. Towards the end of the period technical efficiency, the improvement via individual firms explain the most in aggregate productivity dynamics. The timespan of the data does not cover the economic depression following the 2008 credit crunch. Future research may shed light on how reallocation and industry dynamics work in an environment when firms are facing high uncertainty in investment and hiring decisions.

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# Appendix A Methodology

The economy is a set of $I = 1, ..i, ...N$ firms. Each firm can be characterized by a differentiable production function:

$$Q_i = Q^i(X_i, M_i, \omega_i) - F_i \tag{4}$$

where $X_i$ is a vector of K primary inputs, M a vector of J intermediate inputs and $\omega$ is the productivity term. The prices are $P_i$ and $W_{ik}$ for production and factors respectively. $Y_i$ would be the production going to final demand: $Y_i = Q_i - \sum_j M_j$

The aggregate productivity growth (APG) can be defined as the change in the aggregate final demand net of changes in inputs.

$$APG \equiv \sum_i P_i dY_i - \sum_i \sum_k W_{ik} dX_{ik} \tag{5}$$

expressing equation 5 in growth rates,

$$APG_G = \sum_i \frac{P_i Q_i}{\sum_i P_i Y_i} \frac{dY_i}{Q_i} - \sum_i \sum_k \frac{W_{ik} X_{ik}}{\sum_i P_i Y_i} d\ln X_{ik} \tag{6}$$

As the production share that goes to final demand is not necessarily observable, we need to harness the growth accounting identity, that aggregate final demand is equal to aggregate value added (VA). Hence, we can rewrite 6 as

$$APG_G = \sum_i \frac{VA_i}{\sum_i VA_i} d\ln VA_i - \sum_i \sum_k \frac{W_{ik} X_{ik}}{\sum_i VA_i} d\ln X_{ik} \tag{7}$$

Total differentiation and substituting the production function into eq. 8 gives a decomposition of the aggregate productivity growth into a reallocation term, a technical efficiency term and a fixed cost term.[28]

$$APG = \underbrace{\sum_i \sum_k (P_i \frac{\partial Q_i}{\partial X_k} - W_{ik}) dX_{ik} + \sum_i \sum_j (P_i \frac{\partial Q_i}{\partial M_k} - P_j) dM_{ij} -}_{\text{Reallocation term}} \tag{8}$$
$$- \underbrace{\sum_i P_i dF_i}_{\text{Fixed costs (F)}} + \underbrace{\sum_i P_i d\omega_i}_{\text{Technical efficiency}}$$

The reallocation terms contain difference terms, including the set of primary inputs and the intermediate inputs. There terms are gaps between the marginal product and the marginal cost of the production factors. Hence, reallocation implies an increase in final demand and in APG when it occurs in favour of a firm with higher marginal product relative to the factor prices.

If equation 8 can be rewritten in growth rates with the help of value-added Domar-weights, $D_i$.[29]

[28] For details, see derivation of Lemma 1 in Petrin & Levinsohn (2005)

[29] Here we assume that production function can be written in value-added form.

$$APPG_G = \sum_i \sum_k D_i(\epsilon_{ik} - s_{ik}) d \ln X_{ik} + \\ + \sum_i \sum_j D_i(\epsilon_{ij} - s_{ij}) d \ln M_{ij} - \sum_i D_i d \ln F_i + \sum_i D_i d \ln \omega_i \quad (9)$$

where

$$D_i = \frac{VA_i}{\sum VA_i} \qquad \epsilon_{ik} = \frac{\partial VA_i}{\partial X_{ik}} \frac{X_{ik}}{VA_i} \qquad \epsilon_{ij} = \frac{\partial VA_i}{\partial M_{ij}} \frac{M_{ij}}{VA_i}$$

$$s_{ik} = \frac{W_{ik} X_{ik}}{VA_i} \qquad s_{ij} = \frac{P_j M_{ij}}{VA_i}$$

$$\ln \omega_i = \ln VA_i - \sum_k \epsilon_{ik} \ln X_{ik}$$

So far, we have dealt with productivity growth in continuous time. As firm-level data is available at an annual frequency only, we use Tornqvist indices to approximate continuous changes. The Tornqvist index is an average of current and lagged weights. In the case of the Domar weights, it is calculated as

$$\overline{D}_{it} = \frac{D_{i,t-1} + D_{i,t}}{2}$$

Thus, a discrete time approximation of equation 9 becomes:

$$APG_G = \sum_i \sum_k \overline{D}_i(\epsilon_{ik} - \bar{s}_{ik}) d \ln X_{ik} \quad (10)$$

$$+ \sum_i \sum_j \overline{D}_i(\epsilon_{ij} - \bar{s}_{ij}) d \ln M_{ij} - \sum_i \overline{D}_i d \ln F_i + \sum_i \overline{D}_i d \ln \omega_i \quad (11)$$

To calculate aggregate productivity growth, we assume that production function takes a Cobb-Douglas form with two inputs, capital (K) and labour (L). The function, for sector $s$ and firm $i$, in value added form and real values (superscript $r$):

$$ln\widehat{\omega}_{it} = \ln VA^r_{it} - \epsilon_{sL} \ln L_{it} - \epsilon_{sK} \ln K^r_{it} \quad (12)$$

To estimate the coefficients of the production function we choose the procedure proposed by Levinsohn & Petrin (2003). Denoting the prices of inputs, respectively for labour and capital[30], by ($w$) and ($r$) the aggregate productivity growth rate is calculated as:

$$\widehat{APG_G} = \sum_i \overline{D}_i \Delta lnVA^r_i - \sum_i \left( \frac{r_i K_i}{\sum_i VA_i} \right) \Delta lnK^r_i - \sum_i \left( \frac{w_i L_i}{\sum_i VA_i} \right) \Delta lnL_i \quad (13)$$

[30] The price of a unit labour is the average wage at the firm, while the price of the capital proxied by the user cost of capital. Its calculation is detailed in the Appendix.

As before, the line over variables indicate Tornqvist indices. Equation 13 says that aggregate productivity growth can be calculated as the changes in aggregate value added minus the changes aggregate spending on labour and capital.

Having APG estimated, it can be further decomposed into technical efficiency (TE) and reallocation gaps for labour ($RE_L$) and capital ($RE_K$):

Then, the change in aggregate technical efficiency:

$$TE = \sum_i \overline{D}_i \Delta ln\widehat{\omega}_{it}$$

The reallocation terms, the labour and capital gaps, can also be obtained for specific inputs:

$$RE_L = \sum_i \overline{D}_i \left[ \widehat{\epsilon}_{sL} - \overline{\left( \frac{w_i L_i}{VA_i} \right)} \right] \Delta ln L_i$$

$$RE_K = \sum_i \overline{D}_i \left[ \widehat{\epsilon}_{sK} - \overline{\left( \frac{r_i K_i}{VA_i} \right)} \right] \Delta ln K_i^r$$

As a result, the value added growth can be decomposed into:

$$\underbrace{VA^r}_{\text{growth}} = \underbrace{TE + RE_L + RE_K - F}_{\text{Aggregate productivity growth}} + \underbrace{\sum_i \overline{\left( \frac{r_i K_i}{\sum_i VA_i} \right)} \Delta ln K_i^r + \sum_i \overline{\left( \frac{w_i L_i}{\sum_i VA_i} \right)} \Delta ln L_i}_{\text{Changes in inputs}} \qquad (14)$$

Let $AC_K$ and $AC_L$ denote, the aggregate change in capital and labour, the last two terms of equation 14.

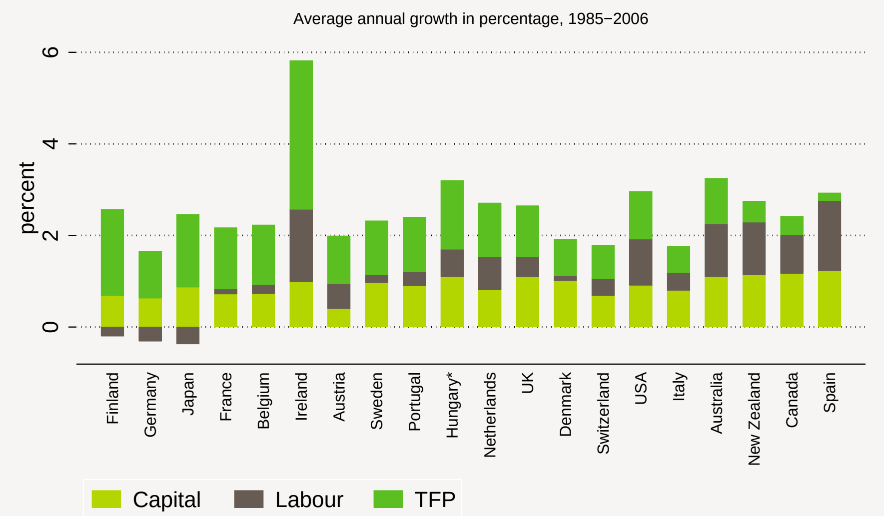
# Appendix B Tables and Figures

**Table 1**
**Contribution percents of sectors to Hungarian GDP in selected years**

| | 1996 | 2000 | 2004 | 2008 |
|---|---|---|---|---|
| Corporate sector | 48.57 | 54.00 | 55.98 | 59.36 |
| Agriculture and Fishing | 2.91 | 2.05 | 1.89 | 1.68 |
| Manufacturing | 19.20 | 21.27 | 20.98 | 20.93 |
| Construction | 2.50 | 2.70 | 3.10 | 3.12 |
| Services | 18.21 | 21.84 | 24.01 | 27.80 |
| Financial sector | 4.61 | 3.36 | 4.01 | 3.85 |
| Government sector | 17.89 | 17.16 | 18.34 | 17.16 |
| Households | 27.87 | 24.52 | 20.55 | 18.53 |
| Non-profit sector | 1.08 | 0.97 | 1.13 | 1.10 |
| GDP | 100.00 | 100.00 | 100.00 | 100.00 |
| Our sample of corporate sector | 46.08 | 51.30 | 52.99 | 56.52 |

Source: Central Statistical Office (KSH)

**Figure 9**
**Contribution factors of growth: international outlook**




*Hungarian figures are for 1994–2008 with Kátay–Wolf (2008) input shares

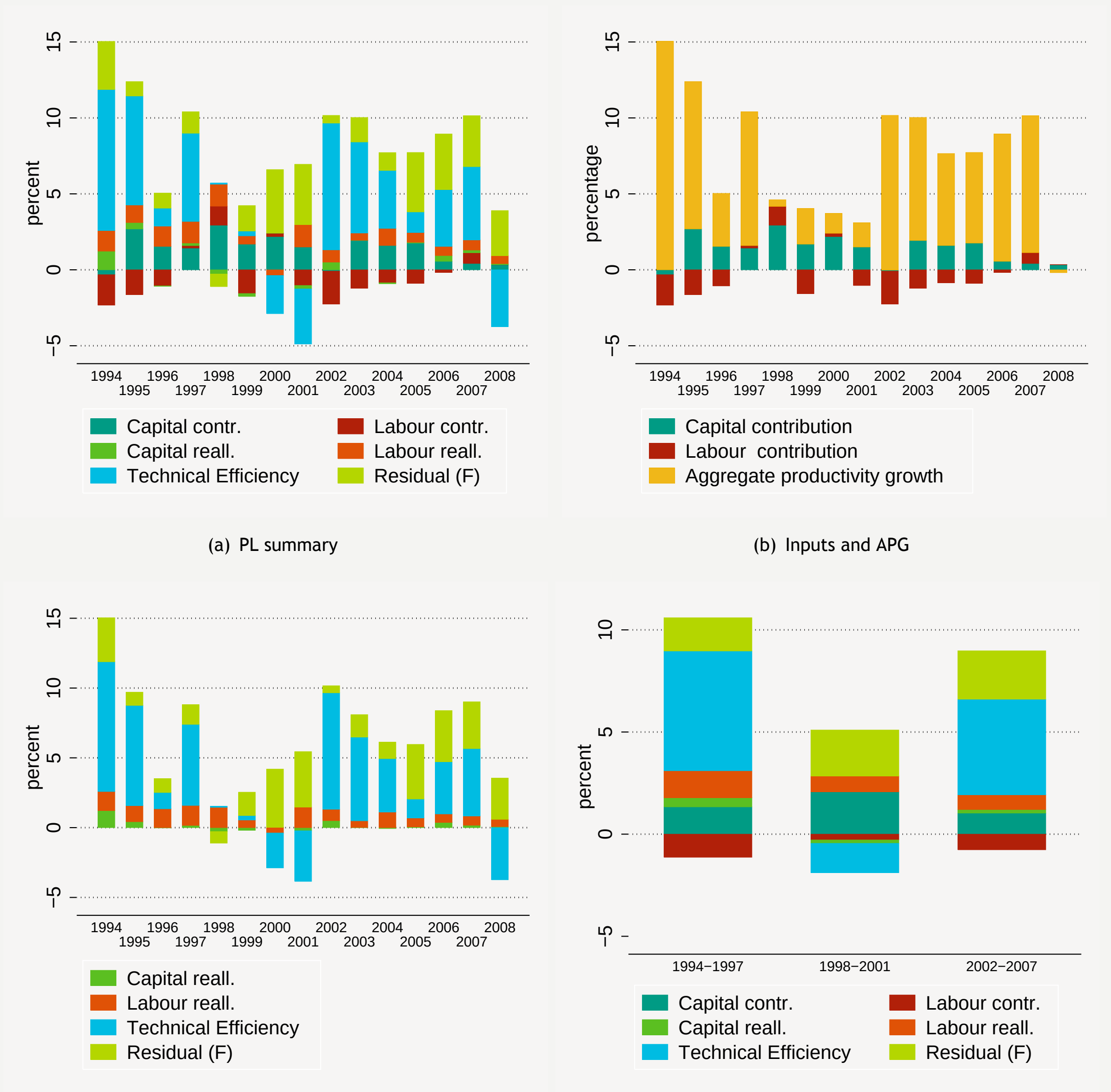
**Figure 10**
**GDP growth in the corporate sector: Role of entry and exit**

**Table 2**
**Number of firms by sector (1994-2008)**

| | | Num. of firms | Num. firms: empl.≥ 5 |
|---|---|---|---|
| | Agriculture and Fishing | | |
| 1 | agriculture, hunting and related service activities | 15897 | 5978 |
| 2 | forestry, logging and related service activities | 2727 | 361 |
| 3 | fishing | 292 | 93 |
| | Manufacturing | | |
| 15 | food products | 8005 | 4241 |
| 16 | beverages and tobacco | 9 | 9 |
| 17 | textiles and textile products | 2373 | 1188 |
| 18 | wearing apparel; dressing and dyeing of fur | 3868 | 1842 |
| 19 | leather and leather products | 951 | 622 |
| 20 | wood and wood products | 4569 | 1999 |
| 21 | pulp, paper and paper products | 737 | 412 |
| 22 | publishing and printing | 10341 | 2622 |
| 23 | coke, refined petroleum products and nuclear fuel | 35 | 14 |
| 24 | chemicals, chemical products and man-made fibres | 1255 | 613 |
| 25 | rubber and plastic products | 2868 | 1613 |
| 26 | other non-metallic mineral products | 2784 | 1251 |
| 27 | basic metals | 554 | 338 |
| 28 | fabricated metal products, except machinery and equipment | 9431 | 4863 |
| 29 | machinery and equipment n.e.c. | 6047 | 2724 |
| 30 | office machinery and computers | 500 | 159 |
| 31 | electrical machinery and apparatus n.e.c. | 1775 | 823 |
| 32 | radio, television and communication equipment and apparatus | 1505 | 651 |
| 33 | medical, precision and optical instruments, watches and clocks | 2491 | 963 |
| 34 | motor vehicles, trailers and semi-trailers | 547 | 340 |
| 35 | other transport equipment | 436 | 174 |
| 36 | furniture; manufacturing n.e.c. | 4594 | 1806 |
| 37 | recycling | 482 | 168 |
| | Construction | | |
| 45 | construction | 58816 | 19980 |
| | Services | | |
| 50 | sale, maintenance and repair of motor vehicles | 22362 | 6768 |
| 51 | wholesale trade and commission trade | 70643 | 16815 |
| 52 | retail trade | 72945 | 17792 |
| 55 | hotels and restaurants | 26928 | 8050 |
| 60 | land transport; transport via pipelines | 13409 | 4199 |
| 61 | water transport | 173 | 60 |
| 62 | air transport | 174 | 39 |
| 63 | supporting and auxiliary transport activities | 7391 | 2283 |
| 64 | post and telecommunications | 2103 | 635 |
| 70 | real estate activities | 38910 | 5077 |
| 71 | renting of machinery and equipment | 3380 | 611 |
| 72 | computer and related activities | 21329 | 3156 |
| 73 | research and development | 3533 | 555 |
| 74 | other business activities | 97139 | 15579 |

**Figure 11**
**Value-added growth rates: CSO versus dataset**

**Figure 12**
**Value-added growth rates in manufacturing**



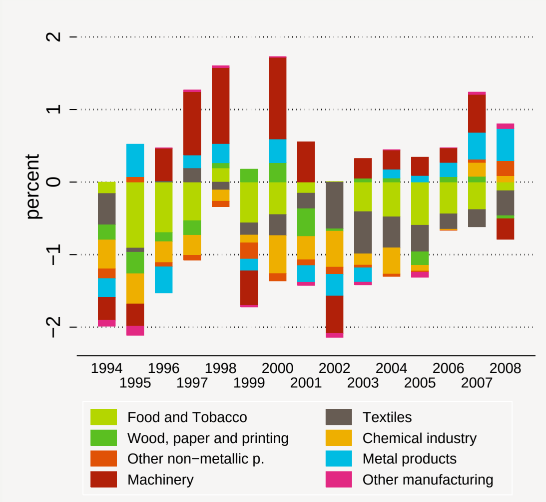

(a) PL summary

(b) Inputs and APG

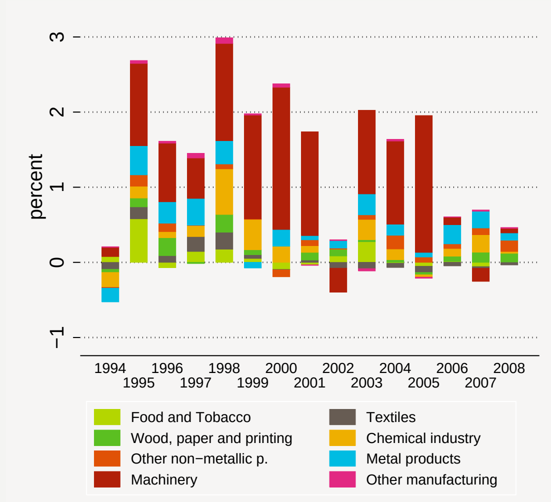
(c) APG: TE+RE-FE

(d) PL by periods

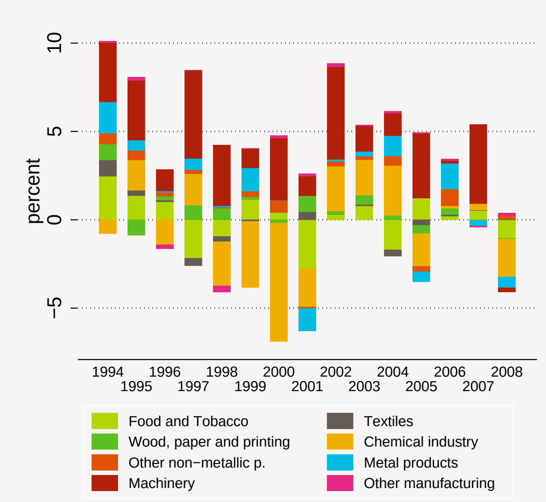
**Figure 13**
**Value-added growth rates in manufacturing: Industry subgroups**



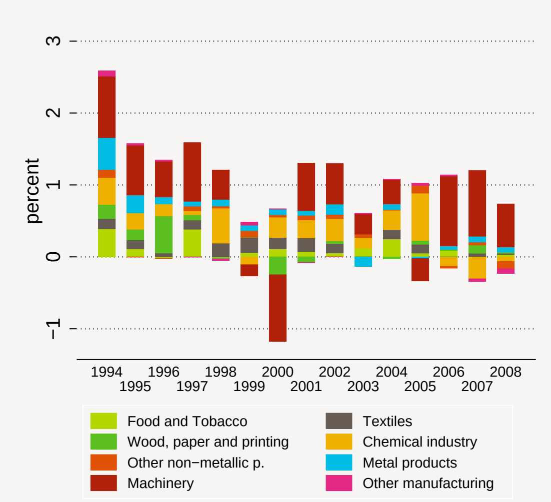

(a) Aggregate labour



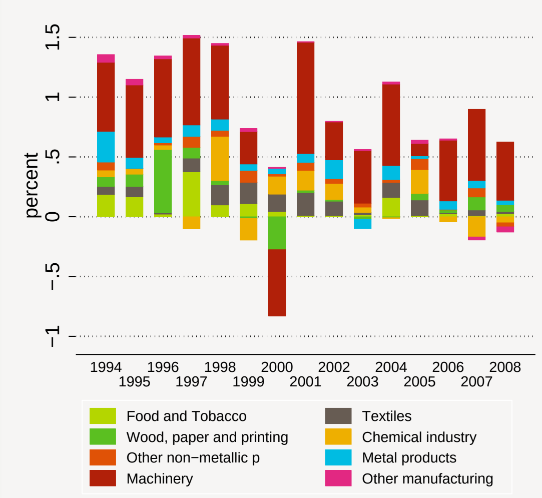

(b) Aggregate capital



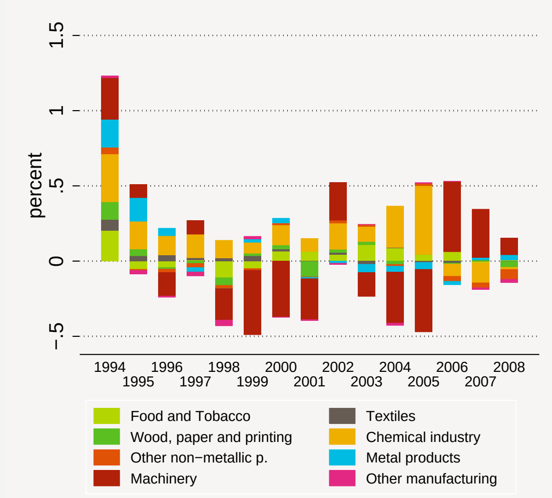

(c) Technical efficiency




(d) Reallocation effects

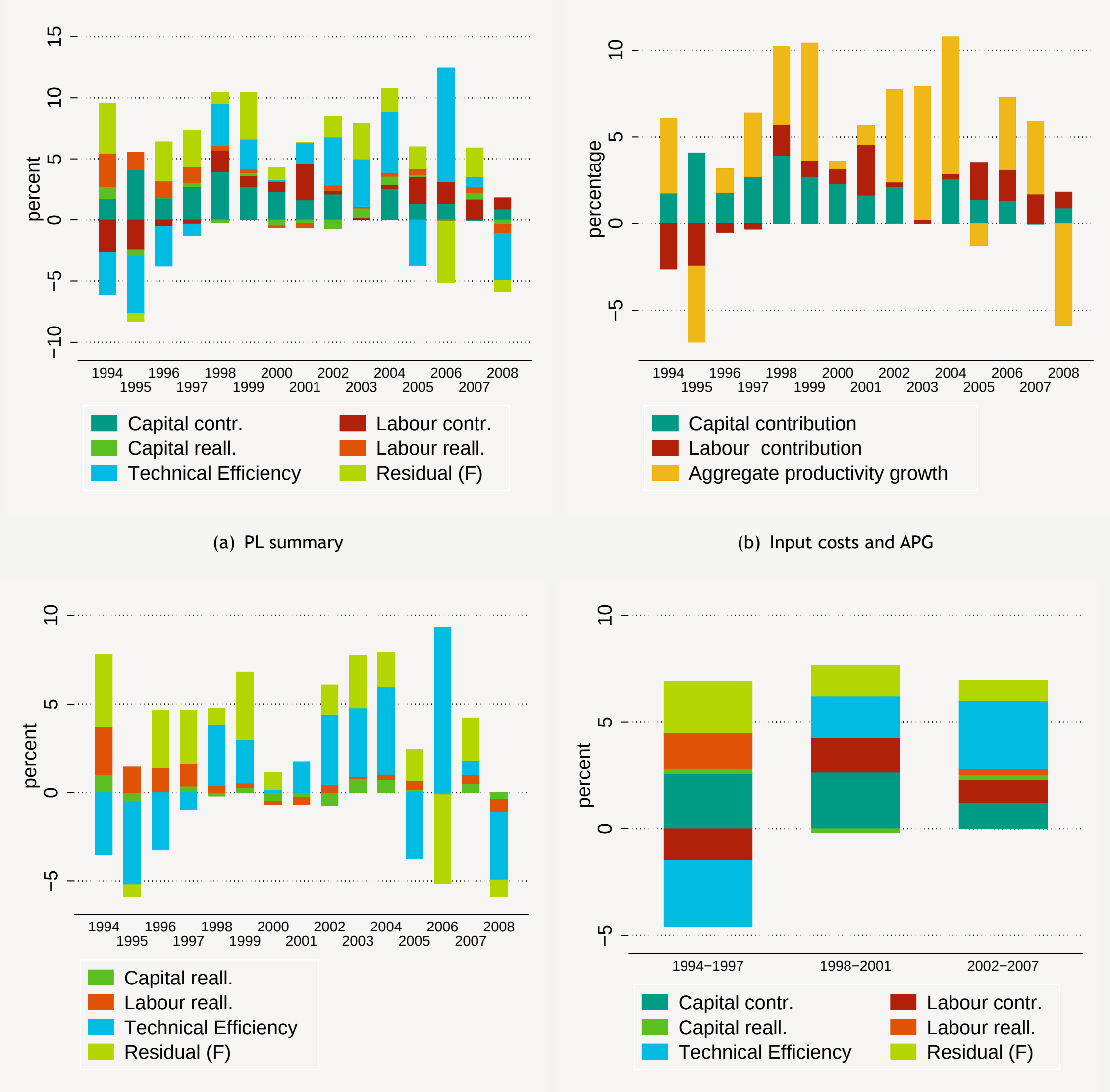



(e) Reallocation: labour




(f) Reallocation: capital

**Figure 14**
**Value-added growth rates in services**



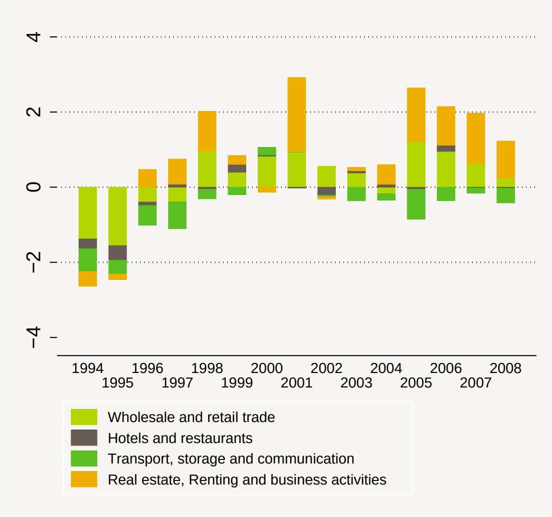

(a) PL summary

(b) Input costs and APG

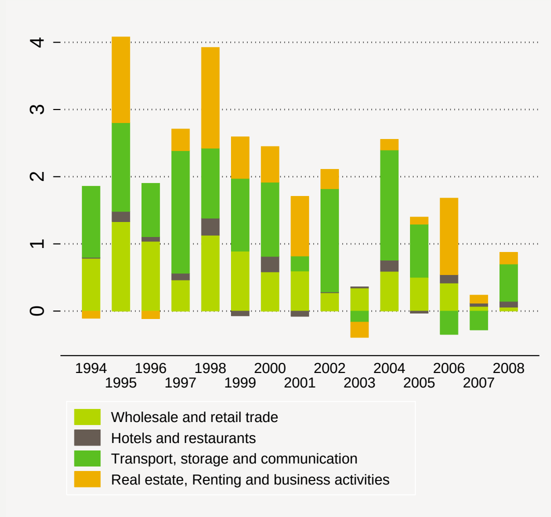
(c) APG: TE+RE-FE

(d) PL by periods

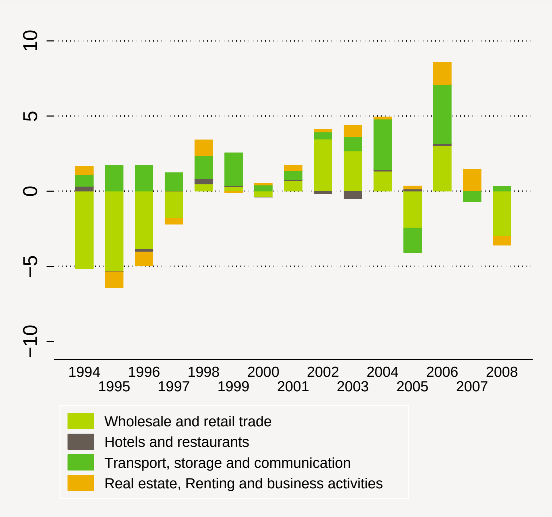
**Figure 15**
**Value-added growth rates in services: Industry subgroups**



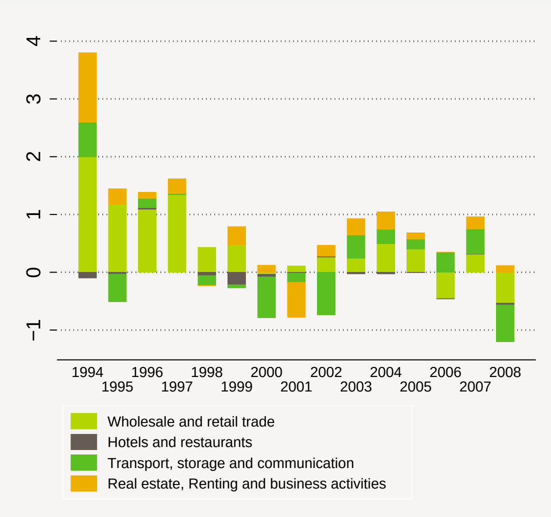

(a) Aggregate labour



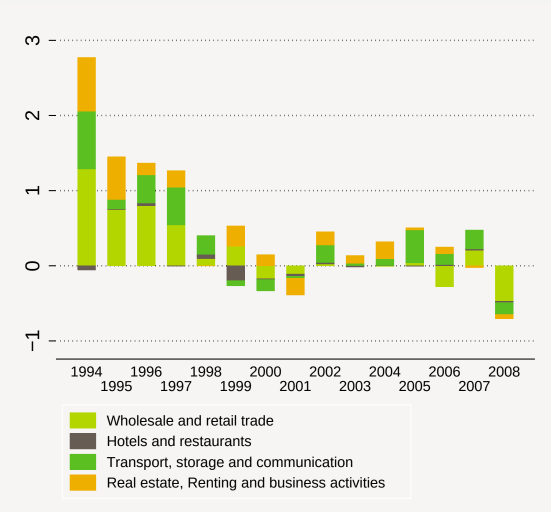

(b) Aggregate capital



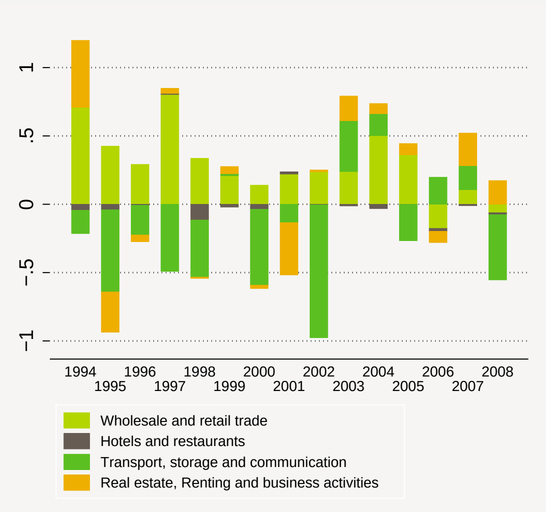

(c) Technical efficiency




(d) Reallocation effects

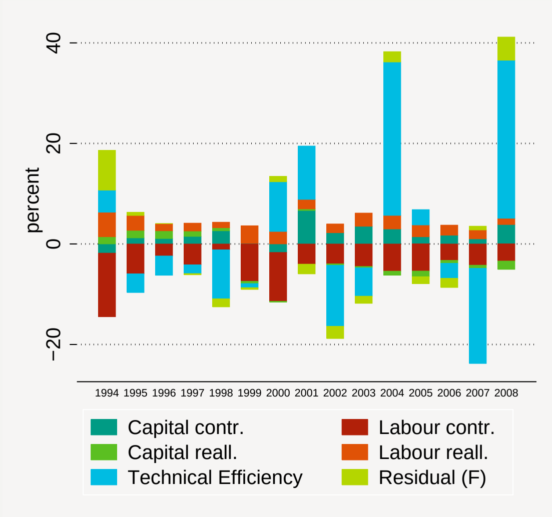



(e) Reallocation: labour

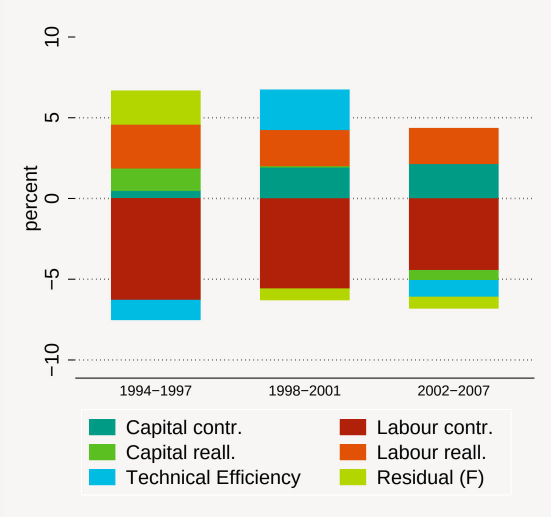



(f) Reallocation: capital

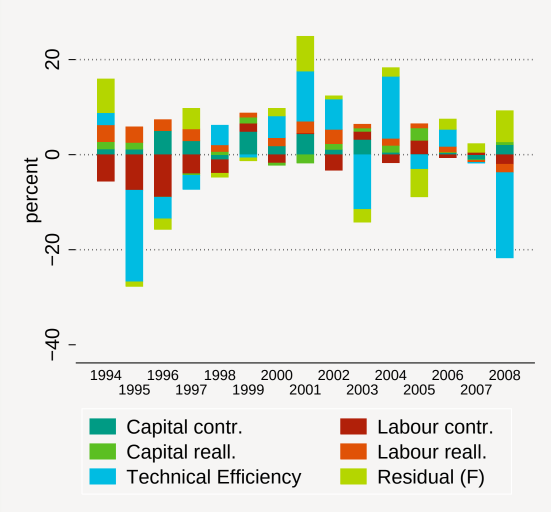
**Figure 16**
**Value-added growth rates**



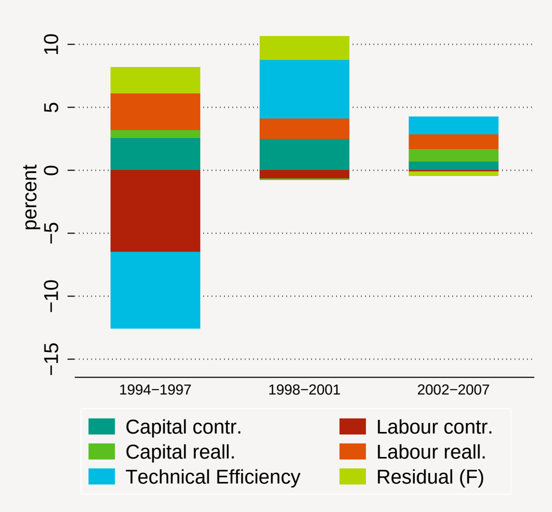

(a) Agriculture




(b) Agriculture by periods

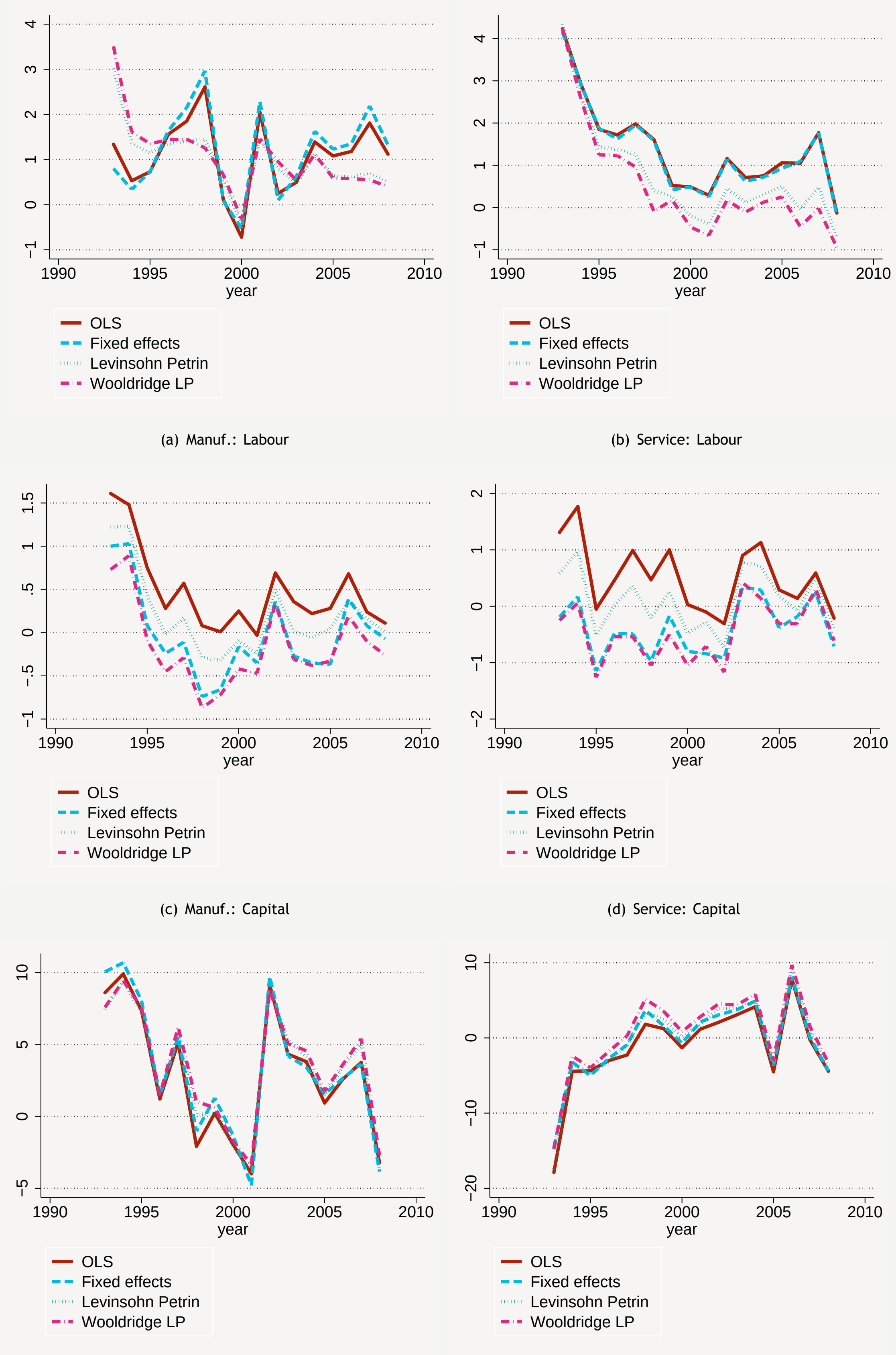



(c) Construction




(d) Construction by periods

**Figure 17**
**Reallocation and Efficiency: various TFP estimations**




(a) Manuf.: Labour

(b) Service: Labour

(c) Manuf.: Capital

(d) Service: Capital

(e) Manuf.: TE

(f) Service: TE

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