AN ANALYSIS OF PAST AND FUTURE GDP GROWTH IN SLOVENIA

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Summary

Following a strong contraction, GDP per capita has grown at a brisk pace since the early 1990s in Slovenia. Over the period 1993-2002 the average annual growth rate was 4.1%. To determine the main driving forces behind this high growth rate we construct series for physical and human capital. Our preferred series for physical capital grows at an annual rate of 6.8% over the period 1993-2002, suggesting substantial capital deepening. Our preferred series for human capital grew at an annual rate of 1.6% over the same period, where human capital is broadly defined so as to include skill biased technological change.

Using our constructed series for physical and human capital, and data on employment and output growth, we then use growth accounting to determine the contributions of these inputs to output growth over the period 1993-2002, and the growth in the residual or 'total factor productivity' (TFP). Using our preferred series we find that (on average) employment, human capital, physical capital and TFP accounted for 0.1, 1.1, 2.0 and 0.8 percentage points of output growth. The contribution by employment is low because there was almost no growth in labor input over the relevant period. Human capital grew not as fast as physical capital, but human capital gets a higher weight in output growth. As a result, human capital growth comes in second after physical capital growth in the growth decomposition. TFP is third after human capital growth. However, our preferred series of human capital includes skill biased technological change. When we use an index of average years of schooling instead, which excludes skill biased technological change, the contribution by human capital drops to 0.3 and the contribution by TFP rises to 1.6 percentage points.

In the process we further find that we do not reject that the substitutability between labor and capital, and between low- and high-skilled workers in Slovenia, is in line with international findings. Skill biased technological change seems to be a bit lower.

Using an educated guess for the inputs in the future, we make a base projection for the growth in GDP per capita over the period 2002-2013. Employment growth is expected to be even lower than in the past, and we project a slowdown and eventual end to capital-deepening in Slovenia. However, the growth in human capital is expected to pick up. Combined with a slightly lower growth in TFP in the future we project an average annual growth in GDP per capita of about 3.6% over the period 2013. The base projection further has higher average wage growth than in the previous period, a fall in the wage of high- relative to low-skilled workers and (on average) a slight drop in the investment-output ratio.

Next, we present a sensitivity analysis of the base projection. Regarding developments in the past, we find that the base projection is the most sensitive to past capital growth. The impact of an alternative series for past human capital growth on future growth is to a large extent offset by an opposing change in projected TFP growth. Regarding future developments, for reasonable lower and upper margins for the growth in the inputs the projected growth rate stays in a band of 3.1% to 4.0%. This is in line with the findings of (most) other studies that make a projection for Slovenia. Their projections range from 3% to 4%.

We conclude with an analysis of convergence to the EU average in terms of GDP per capita. Using an extrapolation of growth rates in the EU-15 over the past 30 years and

assuming that the 10 new member states will grow at an annual rate of 3.6%, we come to a projected average growth rate of 2.3% for the EU over the period 2002-2013. In 2002 Slovenia was at about 76% of average GDP per capita in the EU. To catch up with the EU by 2013, real GDP per capita in Slovenia would then have to grow at an annual rate of 4.9% over the period 2002-2013, or 1.3% faster than in the base projection.

Finally, we conclude with a cautionary note. The preceding analysis builds on short data series of an economy that has witnessed substantial structural changes over the past decade, and can be expected to witness more of them in the future. Hence, our findings from the past and projections for the future should be interpreted with perhaps more than the usual care.

Keywords: physical capital, human capital, growth accounting, total factor productivity, projection, convergence

1. INTRODUCTION[2]

Over the period 1993-2002 average annual growth in the gross domestic product (GDP) per capita in Slovenia was 4.1 percent. What were the determinants of this rapid growth? Furthermore, can we expect these growth rates to continue in the future? And will this be enough for Slovenia to catch up with the EU in terms of GDP per capita in the foreseeable future? This paper tries to give some preliminary answers to these questions. The outline is as follows.

In Section 2 we first consider the growth in GDP, employment, human capital and physical capital in the past. Following Section 2 is a brief *intermezzo* where we consider the substitutability between labour and capital. Section 3 then uses the series of Section 2 for some growth accounting exercises to quantify the role played by these inputs and (the residual) total factor productivity (TFP) in past GDP growth. In Section 4 we turn to the future, where we make a base projection for future output given an educated guess for future inputs. Section 5 presents a sensitivity analysis of this projection. Section 6 then considers convergence with the EU in terms of GDP per capita. Section 7 concludes.

2. GROWTH IN GDP AND INPUTS IN THE PAST

Below we consider past developments in GDP, labour, human capital and physical capital. In the formal analysis below we only consider the period 1993-2002[3]. We restrict the formal analysis to the period after 1992, in part because some series from before are not readily available and/or comparable (due to *e.g.* changes in methodology), but also because they may be of limited use when we believe they are taken from an economy that has witnessed substantial structural change later on[4]. Still, in the informal discussion of the past growth in output and inputs, to add some perspective we do consider some data from the period before 1993. We start with a look at past GDP growth.

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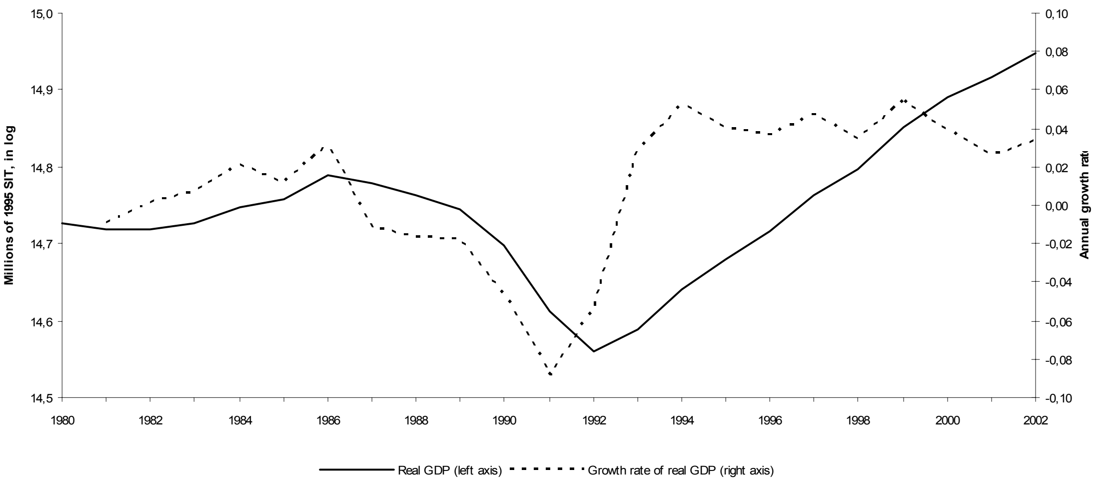
[3] The notable exception is the investment series from before 1993, which are used to obtain an educated guess for the capital stock in 1993.

[4] As the saying goes 'you never step in the same river twice', but here we might be stepping into a different river altogether.

2.1. GDP

Figure 1 gives the development of GDP over the period 1980-2002[5]. The solid line gives (the log of) real output, and the dotted line gives its growth rate. As in most socialist countries, output started to decline by the end of the 1980s/early 1990s[6]. In Slovenia, output started to decline in 1987. The decline accelerated in the period 1989-1991, 1992 still witnessed a strong contraction, and 1993 marked the beginning of the subsequent high growth period[7]. Although the later growth rates were more or less spectacular, it would still take up to 1998 before real GDP surpassed the level of 1986. Indeed, the cumulated contraction of real GDP was a massive 20 percent by 1992.

Figure 1: Gross Domestic Product



Source: Own calculations using data from the Statistical Office of the Republic of Slovenia (SORS) and IMAD.

Note: For 1980-89 we use the growth rate of the so-called (real) 'gross social product' to calculate GDP backwards, using internal data of IMAD. For 1990-1994 we also use internal data of IMAD, but now for real GDP growth. For 1995-2002 we use the latest data on real GDP growth from the SORS.

In the analysis below we are interested in the determinants of the high growth rates over the period 1993-2002, but here we take a brief detour to consider what caused the contraction in output before then. A detailed analysis is beyond the scope of this paper though, the reader is referred to Campos and Coricelli (2002) and Roland (2000) for an analysis of the decline in output in transition economies in general, and Buehrer (1994) and Gligorov (2004) for Slovenia in particular.

[5] For the years 1980-1989 we use the growth rate in the so-called 'gross social product' (GSP) to calculate GDP backwards starting from 1990. The GSP was the socialist counterpart to GDP in Yugoslavia, one of the main differences being that part of the services included in the definition of GDP were not included in the Social Product. Piatkowski (2003) suggests that the growth in the GSP is not a bad proxy for the growth in GDP, partly because the services sector may have been held back during the socialist times.

[6] Section 6 below considers some data for other (former) socialist countries.

[7] In 2001 and 2002 growth slowed down, perhaps mostly due to business cycle factors like a downturn of foreign demand.

The following factors seem to have played a role in the output decline in Slovenia. First, there is the transition from a socialist to a market economy, where frictions caused a "transformational recession" (Kornai, 1993) as production units were reallocated from old to new production sites. We may think of these frictions as being broadly defined so that it includes credit constraints, the 'disorganisation' of production chains *etc.* (see Roland, 2000, for an overview). However, within the group of socialist regions/countries Slovenia was perhaps already the most oriented to the West (in terms of the share of market transactions and trade with Western European economies). This may have limited the 'transformational recession' in Slovenia. Second, the synchronisation in the decline in output in Central and Eastern European Countries (CEECs) was probably not very helpful either, as trade amongst these countries declined. Third, the global economic downturn associated with the (first) Gulf War limited the growth of trade with Western countries. With a large part of its trade already oriented to the West, this may have hit Slovenia relatively hard. Finally, and perhaps most importantly, the declaration of independence and the war in the other republics of Yugoslavia led to a dramatic drop in trade with these republics[8]. According to Buehrer (1994, p.2) '[P]rior to 1991 trade with the rest of Yugoslavia accounted for 25% of all sales of goods in Slovenia. Since then trade with the rest of Yugoslavia has fallen by over 80%.' The decline in demand from other Yugoslav markets put additional pressure on the Slovenian economy to restructure its production processes. From this brief detour we take that on the one hand Slovenia had a head start as far as the transformation to a market economy was concerned. However, on the other hand, the loss of the markets of the other republics of former Yugoslavia still caused a very deep contraction of the Slovenian economy. We consider the factors of the subsequent upswing below.

2.2. Employment

Figure 2 shows the development of employment in full-time equivalents (FTEs)[9]. Like the GDP series above, the employment series shows a dramatic decline in the late 1980s/early 1990s. However, a comparison of Figure 2 with Figure 1 reveals that the drop in employment was not as severe as the drop in GDP. Indeed, the cumulated drop in employment was 13% over the period 1986-1992, compared to a cumulated drop of 20% in GDP.

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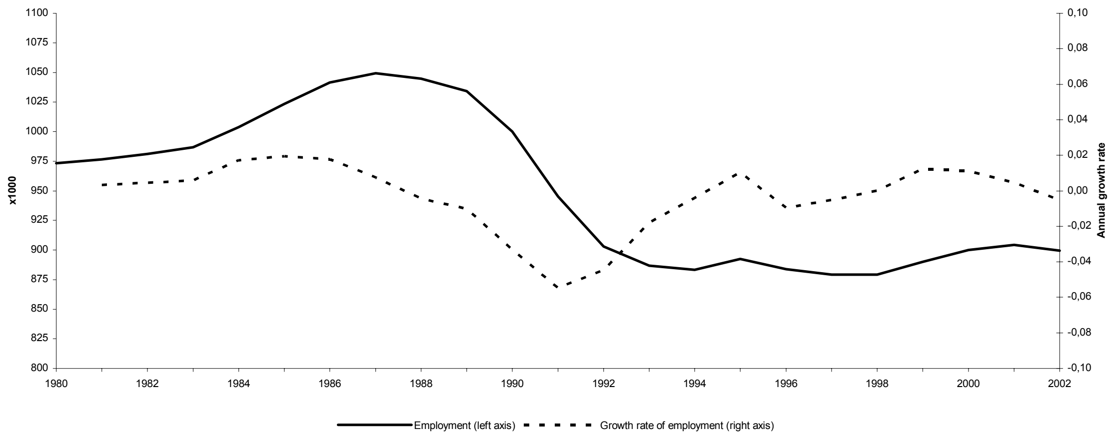
[8] Using a computable general equilibrium model for Slovenia, Buehrer (1994) computes that about two-thirds of the decline in output can be attributed to trade losses.

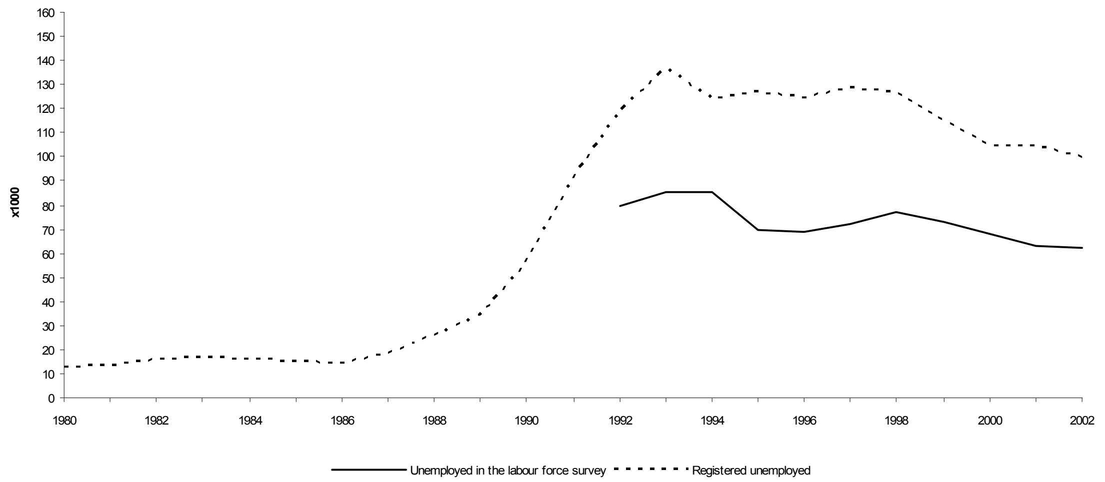
[9] There is a break in the series in 2000 due to a change in methodology. We use the growth rates for the 1992-2000 period and the stock in 2000 according to the old and new methodology to approximate employment in 1992-1999 according to the new methodology. Further, for before 1992 we use the growth rate of employment of the national accounts to calculate the employment in full-time equivalents backwards (internal sources at IMAD).

Figure 2: Employment



Source: Internal data of IMAD.

Figure 3: Unemployment



Source: SORS (2003).

Figure 2 further shows that, since 1992, growth in employment has been negligible. Hence, employment growth cannot have been one of the main driving forces in output growth since then. Furthermore, employment has never recovered to its pre-transition levels[10]. In 1980 employment was about 975,000 FTEs, in 2002 it was about 900,000 FTEs. We cannot explain this drop by the change in the population, which increased in the same period from 1.9 million to around 2.0 million. Part of the answer can be found in the rise in unemployment, see Figure 3. During socialist times, unemployment was kept (presumably artificially) low. Over the period 1986-1993 the number of registered unemployed rose from 14,000 to 140,000 individuals. Since 1993, unemployment has been trending downward, interrupted briefly by a temporary rise around 1998. Figure 3 further shows that the rise in unemployment was less dramatic when we use the ILO definition of unemployment used in the Labour Force Survey (LFS, those actively seeking a job, readily available *etc.*). By 2002 the unemployment rate in Slovenia had fallen to 6%. This is not

[10] Presuming that the data on past employment levels in FTE are not too far off, see also Footnote 8.

particularly high in a market economy. For comparison, the EU-15 and EU-25 had average unemployment rates of 8% and 9% in 2002, respectively. Furthermore, the rise in unemployment can only explain part of the drop in employment, gross participation also fell.

2.3. Human capital

Another determinant of output growth is the growth in the skills of employees. Below we consider three different indicators for the average skill level of employees: i) average years of schooling; ii) average wages relative to the unskilled; and iii) a CES-composite of the skills of low- and high-skilled workers. We first consider these indicators separately, then discuss how developments in these indicators compare to each other, and end with a brief discussion of the pros and cons of one indicator compared to another.

2.3.1. Average years of schooling

Over the 1993-2002 period the average number of years of schooling increased from 11.0 to 11.6 years[11]. This implies an average absolute change of 0.07 years of schooling per annum, or an annual increase of 0.5 percent. For comparison, over the 1990-1998 period the average number of years of schooling in the EU-15 increased from 10.0 to 10.8 years[12]. This implies an average annual absolute change of 0.1, or an annual increase of 1 percent. Hence, considering the growth in the average years of schooling Slovenia did worse than the average of the EU-15.

How do we get from average years of schooling to the impact on output? For this we use the transformation of Hall and Jones (1999). The average skill index of a worker at time *t*, *H(t)*, is given by

$$H(t) = e^{\theta(s(t))},$$

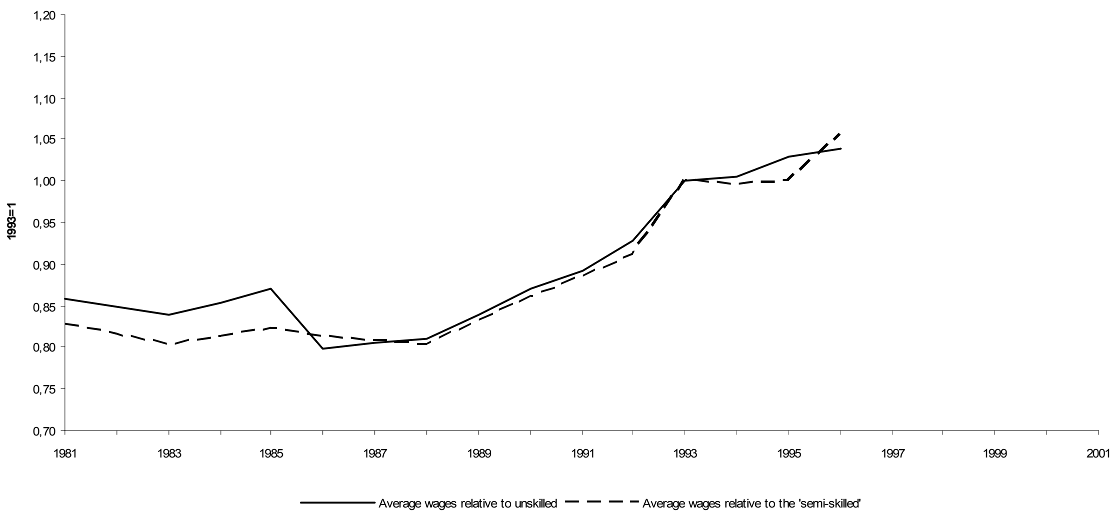
where $\theta(.)$ is a piece-wise linear function of the average years of schooling *s(t)* at time *t*. Motivated by micro-level studies on the returns to education Hall and Jones (1999) come to the following specification for $\theta(.)$[13]. For *s(t)* smaller or equal to 4 years $\theta(.)$ = 0.134 *s(t)*, for *s(t)* in between 4 and 8 years $\theta(.)$ = 0.134*4 + 0.101 (s(t) - 4), and for *s(t)* bigger than 8 years $\theta(.)$ = 0.134*4 + 0.101*4 + 0.068 (s(t) - 8). Hence, although more years of schooling make an individual more productive, the returns to additional years of schooling fall with the years of schooling already accumulated. Using this transformation, we find that the average annual growth in the human capital index over the period 1993-2002 was 0.4%[14].

11 Source: IMAD.
12 Source: own calculations using data reported in Table 2.1 in OECD (2003).
13 See Psacharopoulos (1995) for an excellent introduction to the literature on returns to education.
14 Note that the growth in the average years of schooling may understate the actual growth in the human capital index when we believe that part of the skills acquired during the socialist time became obsolete during the transition, leaving a lower effective initial stock of human capital.

2.3.2. Average wages relative to the wages of the least skilled

Another measure for the average skills of employees is average wages of all employees relative to the wages of the least skilled. The human capital of the unskilled is supposed to remain unchanged over time. Furthermore, note that by taking the wage relative to the unskilled we further control for changes in total factor productivity and the capital-labour ratio[15]. Figure 4 gives two indices for the average human capital of employees, one using average wages relative to wages of the unskilled and one using average wages relative to wages of the 'semi-skilled' (the next lowest skill group in the classification of the SORS)[16]. We also consider average wages relative to the 'semi-skilled' as the unskilled, for example, may not benefit from labour augmenting technological change at all. Both indices are normalised to 1 in 1993.

Figure 4: Average wages relative to the wages of the least skilled



Source: Own calculations using data from SORS (2003).

For the period up to 1997 both series show a more or less similar pattern. Interestingly, wages of the average worker relative to the least skilled appear to fall up to the late 1980s. Although it is hard to believe that the average level of human capital per worker actually fell during this period, it does suggest that the increase in human capital over this period was perhaps limited and/or was not rewarded with higher wages.

From the late 1980s onwards, average wages relative to the least skilled start to rise. This may reflect a rise in human capital. However, this may also reflect a reduction in wage compression following socialist times. Further, it may reflect that individuals with lower skills were hit more severely by the output contraction, for example because they were over-represented in production that was oriented to former Yugoslavia or other transition countries. In any case, the annual growth rate of the average wage relative to the unskilled

[15] Assuming, perhaps erroneously, that there is no capital-skill complementarity. See *e.g.* Krusell *et al.* (2000) for a recent study on capital-skill complementarity.

[16] Source: SORS (2003).

and 'semi-skilled' was substantial over the 1989-1993 period, 4.4% and 4.7%, respectively.

In the formal analysis below we are interested in the period from 1993 onwards. The data on average wages relative to wages of the least skilled are available up to 2001. Relative to the 1989-1993 period, the growth in average wages relative to the least skilled slows down, to 1.5% per year if we take the unskilled as the base, and to 0.8% if we take the 'semi-skilled' as the base[17].

2.3.3. CES-composite of low- and high-skilled workers

Finally, we consider an index of average human capital where we allow for imperfect substitutability between skill types. For simplicity we divide workers into two groups: low- and high-skilled workers. High-skilled workers are individuals with tertiary education (international standard classification of education (ISCED) levels 5 and 6, *i.e.* individuals who have finished higher vocational training or have obtained a university degree). Low-skilled workers are individuals without a tertiary education.

Effective labour in production at time t, $N^e(t)$, is given by the following CES (constant-elasticity-of-substitution) function

$$N^e(t) = \left(\alpha(A_H(t)N_H(t))^\sigma + (1-\alpha)(A_L(t)N_L(t))^\sigma\right)^{\frac{1}{\sigma}},$$

where α denotes a distribution parameter, $A_H(t)$ and $A_L(t)$ denote high- and low-skilled workers augmenting technological change at time t, $N_H(t)$ and $N_L(t)$ denote the number of high- and low-skilled workers at time t, and σ determines the (constant) elasticity of substitution between low- and high-skilled workers $\rho \equiv 1/(\sigma-1)$. When $\sigma \uparrow 1$ then $\rho \rightarrow -\infty$, the two skill-types are perfect substitutes. When $\sigma = 0$ then $\rho = -1$, the Cobb-Douglas case. When $\sigma < 0$ then $\rho > -1$, and the two skill types are said to be complements. In the limit $\sigma \rightarrow -\infty$ and $\rho \rightarrow 0$, low- and high-skilled labour are 'perfect' complements.

Using the fact that the expression for effective labour has constant returns to scale, we may divide this expression through by total employment $N(t) \equiv N_L(t) + N_H(t)$ multiplied with low-skilled labour augmenting technological change $A_L(t)$ to obtain a more convenient expression consisting of 'raw' labour, low-skilled labour augmenting technological change and a 'human capital' index[18]

$$N^e(t) = \left(\alpha(A'_H(t)s_H(t))^\sigma + (1-\alpha)(s_L(t))^\sigma\right)^{\frac{1}{\sigma}} A_L(t)N(t),$$

where $A'_H(t)$ now denotes skill-biased technological change, $A'_H(t) \equiv A_H(t) / A_L(t)$, and $s_H(t)$ and $s_L(t)$ denote the shares of high- and low-skilled labour in employment, respectively.

[17] Furthermore, since we are supposing that the growth in relative wages reflects the growth in relative productivity's we need not apply any transformation.

[18] The human capital index so defined includes skill-biased technological change.

Denote the labour costs of low- and high-skilled workers at time t by $w_L(t)$ and $w_H(t)$, respectively. Cost minimisation then implies the following relation between the demand for low- and high-skilled labour and their relative labour costs[19]

$$\log(w_H(t)/w_L(t)) = \log(\alpha/(1-\alpha)) + \sigma\log(A'_H(t)) + (\sigma-1)\log(s_H(t)/s_L(t)).$$

Assuming that $A'_H(t)$ is of the form $A'_H(0)(1+g)^t$, where $A'_H(0)$ denotes the initial level of the skill bias in technological change and g denotes its annual growth rate[20], and assuming that g is sufficiently small so that we can use the approximation $\log(1+g) \approx g$, we can rewrite the above expression into the estimating equation

$$\log(w_H(t)/w_L(t)) = c + \sigma g t + (\sigma-1)\log(s_H(t)/s_L(t)) + \varepsilon_t,$$

where $c \equiv \log(\alpha A'_H(0)^\sigma/(1-\alpha))$ and ε_t denotes an (independently and identically distributed) disturbance term. By using data on relative wages and relative employment shares we can estimate the parameters of interest.

In Figure 5 we first consider the data to be used in the estimation[21]. We observe a rise in the relative supply of high-skilled workers, the index rises from 1 in 1993 to 1.18 in 2002 (the share of high-skilled workers rises from 16.0% in 1993 to 18.4% in 2002). However, despite the rise in the relative supply of high-skilled workers their relative wages also increased, from 1 in 1993 to 1.1 in 2002[22,23]. This suggests we have skill-biased technological change[24]. An informative period for the substitutability between the two types of labour further seems to be the period 1998-2000, where we witness a steep decline in the relative wages of high-skilled workers following a steep rise in the relative supply of high-skilled workers[25].

[19] All derivations used in the paper are available from the author on request.

[20] A higher order term for the time trend was not supported by the data.

[21] Source: own calculations using SORS data on wages for workers with different skill types and the number of workers per skill type.

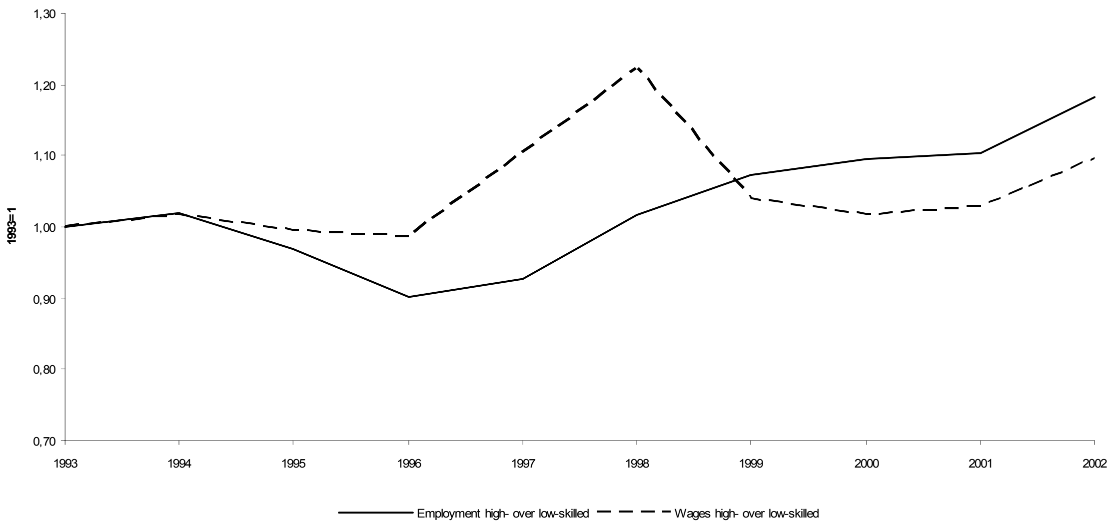
[22] For a similar finding for the U.S., see *e.g.* Acemoglu (2002a).

[23] We will use relative gross wages as a proxy for relative labour costs in the estimations. One imperfection with this proxy is that we do not take into account the ‘payroll tax’ introduced in the mid 1990s. The payroll tax is progressive and was not fully indexed to the growth in average gross wages.

[24] Or that the human capital of high-skilled workers increased more than the human capital of low-skilled workers (in percentage terms) over this period. Again, another possibility is that high-skilled workers are closer substitutes to capital than low-skilled workers. However, given the sparse information on the capital stock in Slovenia over the relevant period we do not consider this possibility here. We note though that the rise in relative wages of high-skilled workers is consistent with the rise in the capital-output ratio in our constructed capital series (see below) combined with capital-skill complementarity.

[25] I first calculated the average wage for individuals with a tertiary education and then calculated the average wage of the low-skilled as a residual using data on average wages for all workers and the shares of low- and high-skilled workers in employment. However, the sudden rise and drop in the relative wages of the high-skilled around 1998 is not an artefact of the construction method. The relative wages of individuals with a university degree (and to a lesser extent the relative wages of individuals with higher vocational training) show a similar pattern around 1998, see Table 13.5 in SORS (2003).

Figure 5: Wages and employment of low- and high-skilled



Source: Internal data of IMAD.

Table 1: Substitutability between low- and high-skilled labor

Estimated parameter	σ g	σ - 1	R^2	Durbin-Watson
Using $S_H(t)/S_L(t)$	0.011 (0.011)	-0.148 (0.402)	0.14	1.70
Using $S_H(t-1)/S_L(t-1)$				
unrestricted	0.020 (0.008)	-0.871 (0.310)	0.60	2.13
σ-1= -.660	0.017 (0.006)	-0.660 -	0.57	2.16

Note: Standard errors in parentheses; estimation period: 1993-2002.

The estimation results using these data are given in Table 1. For comparison, reviewing the literature on the demand for low- and high-skilled labour Katz and Autor (1999) suggest that the elasticity of substitution between low- and high-skilled labour is around -1.5, or σ is around 0.33, and the annual rate of skill-biased technological change is around 3%[26].

When we estimate the contemporary relation between the relative wages and the relative supply of high-skilled workers we find a value of σ = 0.85, which would imply a substitution elasticity of about -6.7. Compared to the studies reviewed by Katz and Autor (1999), this would be a relatively high substitutability between low- and high-skilled labour. Furthermore, we find an annual rate of skill-biased technological change σg of about 1%, which seems relatively low. Before we draw any conclusions from this, we note that the role of both factors is measured relatively imprecisely. Indeed, only 14 percent of the deviation from the mean is 'explained' in the estimation[27].

[26] Clearly, there may be some difficulties in making international comparisons due to differences in the quality and classifications of education types across countries.

[27] As an experiment I introduced a dummy for the year 1998, which seems to be an "outlier". However, collinearity between the regressors then becomes a (more) serious problem resulting in very imprecise coefficient estimates. Indeed, we then remove the most informative data point in the series regarding the substitutability between the two skill types.

Using one period lagged rather than the contemporary relative supply of high-skilled workers greatly improved the 'explanatory' power of the estimating equation (a casual look at Figure 5 suggests that perhaps wages respond to the relative supply with a delay). Using the one period lagged value of the relative supply of high-skilled workers suggests a value $\sigma = .13$, which would imply a substitutability between low- and high-skilled labour in production that is somewhat lower than suggested by Katz and Autor (1999), although it clearly does not differ significantly from the value suggested by Katz and Autor (1999). Note, however that in this case we do reject the null-hypothesis that low- and high-skilled labour are perfect substitutes (σ=1) at the 95-percent confidence level. We further find an annual rate of skill-biased technological change of 2.0% per year.

Finally, as another alternative, suppose that we fix the substitutability at the value suggested by Katz and Autor (1999) (which we do not reject in the unrestricted regression). We then find an annual rate of skill-biased technological change of 1.7% per year.

Concluding, we find that using lagged relative employment shares greatly improves the 'explanatory' power of the estimation. We do not reject that the substitutability of low- and high-skilled labour is in line with the international findings of Katz and Autor (1999), but the rate of skill-biased technological change seems to be somewhat lower in Slovenia.[28,29]

We proceed by constructing a human capital index using the above mentioned regression results for the substitutability between low- and high-skilled labour with lagged employment shares. The (poor) estimation results using contemporary employment suggest a rise in the human capital index of 0.6% per year. The unrestricted estimation results using lagged employment suggest a rather dramatic rise in the human capital index of 4.6% per year. Finally, the 'middle-of-the-road' estimation with σ fixed at the 'international' value of 0.34 suggest an annual rise in the human capital index of 1.6% per year, which is our preferred estimation.

We close this section by noting that, although we refer to the index as a 'human capital' index, it is in fact a composite of human capital and skill-biased technological change. Still, we can argue that the index reflects the role of skills in final output. With less high-skilled workers one also misses out on the skill-biased technological change for these workers.

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[28] One explanation as to why skill-biased technological change is lower in Slovenia than in other countries on average could be the idea of 'directed technological change' of Acemoglu (2002b), where the invention and adoption of technologies is directed to factors that are relatively abundant. The relatively low share of Slovenians with a tertiary education (see Jongen, 2004a, for a comparison of Slovenia with the EU-15 countries on many variables) may have limited the bias of technological change towards high-skilled workers in Slovenia.

[29] One further issue is whether we are estimating a 'true' or a 'spurious' relation (Granger and Newbold, 1974). With only 10 observations, we cannot reject either hypothesis. One the one hand, we find that we cannot reject that both log relative wages and log lagged relative employment are integrated of the first order (have a unit root). However, on the other hand, we also cannot reject that they are cointegrated (they 'share the same random walk'). As we have no other data, we will assume that we are in fact estimating a 'true' relationship.

2.3.4. A comparison of the human capital indices

In the sections above we considered the growth in 3 human capital indices over the period 1993-2002. Using (the Hall and Jones transformation of) average years of schooling as an indicator of average human capital we obtain an annual growth rate of human capital of only 0.4% over the period 1993-2002, somewhat below the annual average of the EU-15 over the period 1990-1998.

Using average wages relative to the least skilled suggests an annual growth rate of the human capital index between 0.8% (using ‘semi-skilled’ as a base) and 1.5% (using “unskilled” as a base). Using a CES-weighted average of low- and high-skilled workers suggests an annual growth rate in the human capital index between 0.6% and 4.6%, with 1.6% in our preferred estimation.

Average years of schooling gives a lower growth in the human capital index than the other two indices because it does not include skill-biased technological change. Using average wages relative to the least skilled one implicitly incorporates skill-biased technological change in the human capital index. The CES-weighted human capital index of low- and high-skilled labour explicitly includes skill-biased technological change. Given the relatively large gap in the growth in the first and the latter two human capital indices, the role of human capital in past GDP growth in Slovenia basically depends on whether one defines human capital as including skill-biased technological change.

Which series are to be preferred? We prefer to use the CES-weighted series of low-and high-skilled labour. We prefer the CES-weighted series to the average years of schooling because it includes the interaction between technological change and the share of high-skilled workers and because it allows for imperfect substitutability between different worker types. By using average years of schooling, one implicitly assumes that workers are perfect substitutes, which we reject in Section 2.3.3. We also prefer the CES-weighted series to the average wages relative to the least-skilled wages series because the latter also assumes perfect substitutability between skill types. A drawback of the CES-weighted series vis- a -vis the average wages relative to the wages of the least-skilled series is that it does not take into account the full distribution of skill types. However, note that the average annual growth rate in the human capital index in the latter two indices are quantitatively similar (for the preferred estimation of the CES-weighted index)[30].

[30] Another paper that constructs a human capital index series for Slovenia is Bovha Padilla and Padilla Mayer (2002) who try to construct a human capital index a la Collins and Bosworth (1996). Collins and Bosworth (1996) use rates of return combined with years of schooling required for a few education classes to calculate an average wage relative to the least skilled without taking into account skill-biased technological change. Bovha Padilla and Padilla Mayer (2002) use relative wages of skill types and average years of schooling per skill type to calculate rates of return. They then calculate what is in my opinion a faulty index. Indeed, if the point is to get to some average wage relative to the least skilled, one can readily take the wages they start with. I tried to construct a Collins and Bosworth (1996) index for human capital in Slovenia using the rates of return suggested by Bovha Padilla and Padilla Mayer (2002), and using the shares of the skill types and average years of schooling per type of education supplied by Tomaž Kraigher (IMAD) (details available on request). The result is an index that grows at an annual rate of 0.4% over the 1992-2000 period, compared to only 0.1% in the study of Bovha Padilla and Padilla Mayer (2002). For completeness, using the series for low- and high-skilled employment and wages of Section 2.3.3 I come to a Collins and Bosworth (1996) human capital index that grows at 0.6% annually over the 1993-2002 period.

2.4. Physical capital

No official physical capital series for Slovenia exists[31]. Hence, below we construct our own series for the capital stock. We consider two methods: i) the perpetual inventory method using past real investment series; and ii) the implicit capital stock from the equalisation of the marginal product of capital to its user cost. We conclude with a brief comparison of these two series and the findings of other studies on the capital stock in Slovenia.

2.4.1. Capital series using the perpetual inventory method

In the perpetual inventory method we accumulate investments forward, starting with an initial guess for the capital stock and assuming a particular depreciation rate. Specifically, the capital in year *t*, *K(t)*, is supposed to be given by

$$K(t) = (1-\delta)K(t-1) + I(t),$$

where *I(t)* denotes gross real investment in year *t*, and δ denotes the depreciation rate of capital (typically assumed constant, but see below).

We start with an initial guess for capital in the base year of 1972. From various statistical yearbooks of the SORS we can construct a value for GDP in 1972 in 1995 prices. We come to a GDP in 1972 of SIT 1,511 billion (in 1995 prices). Suppose that the capital-output ratio in 1972 was 2.14[32], we then obtain an initial stock of capital of SIT 3,326 billion in 1972 (in 1995 prices). Assuming a different capital-output ratio in 1972 only has a minor effect on the capital series for the period 1993-2002.

As gross investment we take gross fixed capital formation (GFCF) in current prices from the National Accounts, converted to real terms with the implicit deflator for gross fixed capital formation from the National Accounts for the period 1991-2002 and the producer price index for the period 1972-1990 (no implicit GFCF deflator was available), with the price for 1995 normalised to 1.

Regarding depreciation, for the years 1972-1986 and 1993-2002 we assume an annual depreciation rate of capital of 0.075. Data from the capital count of private companies in Slovenia, which covers most private-sector firms, suggest an average depreciation rate of 7.5% per annum over the 1995-2001 period. This is somewhat above the 'typical' value of 6% used for developed countries (see *e.g.* Caselli, 2003). This may be due to the fact that

[31] Slovenia is but one of many other countries without an official capital series. In Rapid Report No. 107 of the SORS published on 29 April 2002, the SORS reports preliminary estimates for the capital stock in 1999. Since then, there have been no updates on the official capital stock in Slovenia (personal communication with the SORS). The reported capital-output ratio of more than 3 times GDP seems relatively high however (intangible assets are only a small part, so this does not explain the relatively high figure, furthermore residential housing also appears to be largely excluded). For a similar conclusion about the official capital series in Hungary, see Pula (2003).

[32] As the starting value for the capital-output ratio in 1972 we take the value we obtain in 2002, 2.14. We can motivate this by assuming that the capital-output ratio was as close to its balanced growth path in 1972 as it was 30 years later. For a starting value of 2.00, 2.14 and 2.28 in 1972 we obtain a capital-output ratio in 1993 (the first year for the formal analysis) of 1.69, 1.70 and 1.71 respectively. Hence, the exact starting value for 1972 is quantitatively not that important (due to depreciation of this initial stock over the subsequent 20 years before we get to 1993).

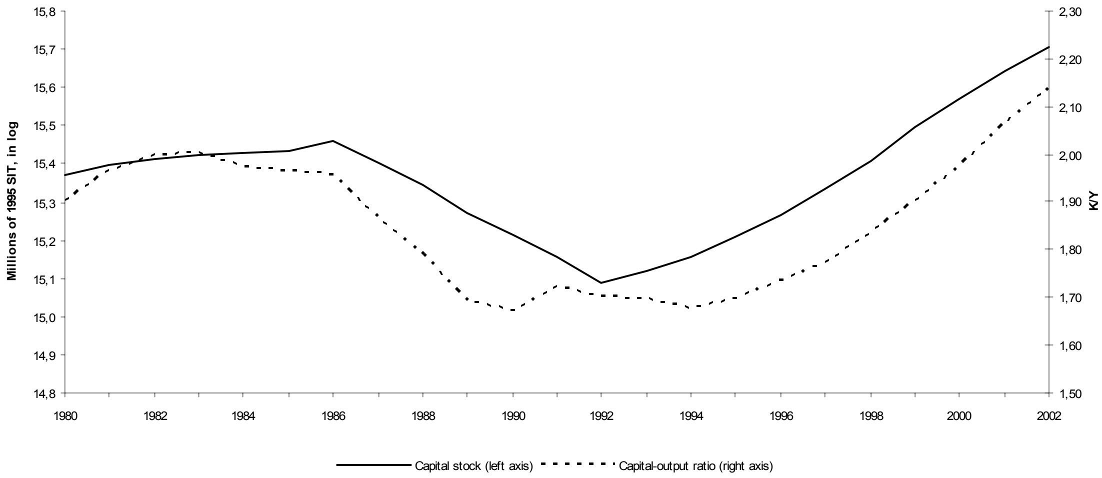
the capital count of private companies does not cover capital with a low depreciation rate (*e.g.* roads). However, we may expect a somewhat higher depreciation rate in Slovenia due to above average scrapping of obsolete capital units following the transition. Finally, we note that compared to other studies on the Slovenian capital stock, our depreciation rate is pretty conservative. Bovha Padilla and Padilla Mayer (2002), Doyle *et al.* (2001), Mićković and Vasle (2004) and Piatkowski (2003) use a depreciation rate of 10%, 8%, 10% and 7.5%, respectively.

In the period 1987-1992 we assume double depreciation of the capital stock, *i.e.* 15% annually, due to intensified restructuring in the initial phase of the transition. Combined with the decline in real investment during this period, the cumulative drop in the capital stock is 32%. This decline is somewhat higher than the cumulated drop of 26% in the Slovenian capital stock calculated by Doyle *et al.* (2001) over the same period.[33]

Another way to deal with the impact of the contraction/transition period of 1987-1992 on the capital stock is to use growth accounting (following a lead from Pula, 2003). We consider growth accounting in more detail in Section 3 below. Growth accounting is normally used to calculate the growth in total factor productivity (TFP) as a residual, that is the growth in GDP not accounted for by the growth in (effective) labour and capital. Here, we use it to calculate the growth in capital as a residual, assuming a particular growth rate for TFP. Supposing that there was no growth in human capital in the period 1986-1993 (perhaps not unreasonable, consider for example the growth in average wages relative to the least skilled in Figure 4 above), no change in total factor productivity (due to the disruption of the workings of the economy), and taking the employment series given above, we come to a cumulated drop in the capital stock of 43% when we use the actual labour and capital income share for their respective output elasticity's and 39% when we use a constant output elasticity of labour and capital of 0.7 and 0.3, respectively (more on this below). This cumulative drop in capital is quite a bit larger than when we use double depreciation. However, the growth accounting exercise depends crucially on our assumption regarding TFP growth. For example, one can easily imagine a drop in TFP in these years. An annual drop in TFP of 0.5% during the period 1987-1992 would suffice to come to the cumulated drop of 32% in the capital stock we obtained when using double depreciation.

[33] Although a drop of 32% is dramatic, this may not be unrealistic. Indeed, Sinn and Sinn (1992) reported a drop of capital in East Germany of 50-75% after the reunification. However, East Germany was special in the sense that the government was striving for substantial wage equalisation between West and East Germany after the reunification.

Figure 6: Capital stock and capital-output ratio



Source: Own calculations using data from SORS and IMAD.

Note: See the main text for the construction method.

The resulting capital stock series, using double depreciation, is given in Figure 6. After an increase in the capital stock until the mid-1980s we observe a steep drop from 1987 to 1992 (due to higher depreciation and lower investment). From 1993 on, capital starts to grow relatively fast again. Over the period 1993-2002 we find an annual growth in the real capital stock of 6.8%. Still, it takes until 1999 for the capital stock to exceed the level of 1986 in real terms. Figure 6 also gives the corresponding capital-output ratio. The capital-output ratio shows a similar pattern as the capital stock, suggesting that the swings in the capital stock were bigger than the swings in output. Over the period 1993-2002 the capital-output ratio rises from 1.70 to 2.14, suggesting substantial capital deepening over this period.

2.4.2. Capital series using the optimality condition

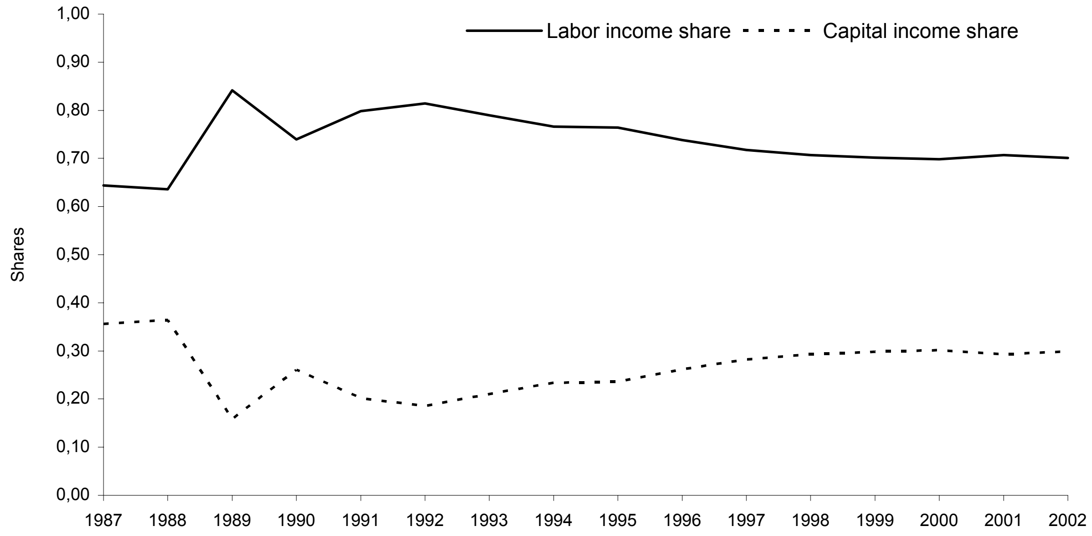
As an alternative, we can derive a series for the capital stock from the optimality condition that the marginal product of capital equals its user cost, following a lead from Mrkaic (2002).[34] Suppose that output is given by a Cobb-Douglas production function of labour and capital (which we do not reject, see the *intermezzo* below[35]). Furthermore, assume that the marginal product of capital equals the user cost of capital. The capital-output ratio then equals the capital income share over the user cost of capital[36].

[34] Mrkaić (2002) uses the marginal productivity condition only to calculate an initial capital stock, and then uses the capital accumulation equation of the previous section to calculate capital growth. Here we use the marginal productivity condition for the whole period.

[35] Furthermore, we obtain this result from the labour demand equation where we do not use our capital series. All we demand from capital in the estimation of the labour demand equation is that capital is paid its marginal product and that the production function has constant returns to scale.

[36] For the more general CES production function, the optimal capital-income share is a function of the substitution elasticity as well.

Figure 7: Labour and capital income share



Source: Own calculations using National Accounts data from various issues of the Statistical Yearbook of the SORS.

Note: The labour income share is calculated as the compensation of employees x (self-employed+employees)/employees/(GDP–(indirect taxes–subsidies)). The capital income share is the complement of the labour income share.

Figure 7 plots the labour and capital income share. The labour income share is defined as the total remuneration of labour (including imputed labour costs for self-employed, self-employed are not machines[37]), over gross domestic product minus indirect taxes plus subsidies. The capital income share is the complement of the labour income share. The series show a substantial drop in the capital income share in the late 1980s, and a subsequent recovery. Over the period 1992-1999 the capital income share rises from 0.19 to 0.30. Since 1999 the capital income share hovers around 0.30, a level comparable with the long-run level in many OECD countries. Below we compute capital series using these capital income shares. However, in Jongen (2004b) we argue that the drop in the capital income share would require an unrealistic change in the capital-output ratio and/or an unrealistic substitution elasticity between labour and capital. Therefore, we also consider the case that the capital income share is a bad proxy for the elasticity of output with respect to capital over the period 1993-2002 (capital was not paid its marginal product), and use a constant value of 0.3 instead.

The other variable of interest is the user cost of capital. Unfortunately, the user cost of capital is not directly observed in the market. However, parts of its determinants are. We use these to construct the so-called Jorgensen cost of capital, $p_k(t)$. Consider the following intuitive derivation of the user cost of capital (see *e.g.* Jorgenson and Stiroh, 2000). Suppose we have an investor that is indifferent between two investment opportunities: 1) purchasing a unit of capital which depreciates at rate and then having the option of selling

[37] We use SORS data on the number of self-employed relative to employment in full-time equivalents to inflate the labour income share to include the self-employed, assuming that all self-employed work full-time.

this piece of capital in the next period; or 2) investing in an alternative which earns him or her a nominal return of *r(t)*. For the investor to be indifferent we need to have[38]

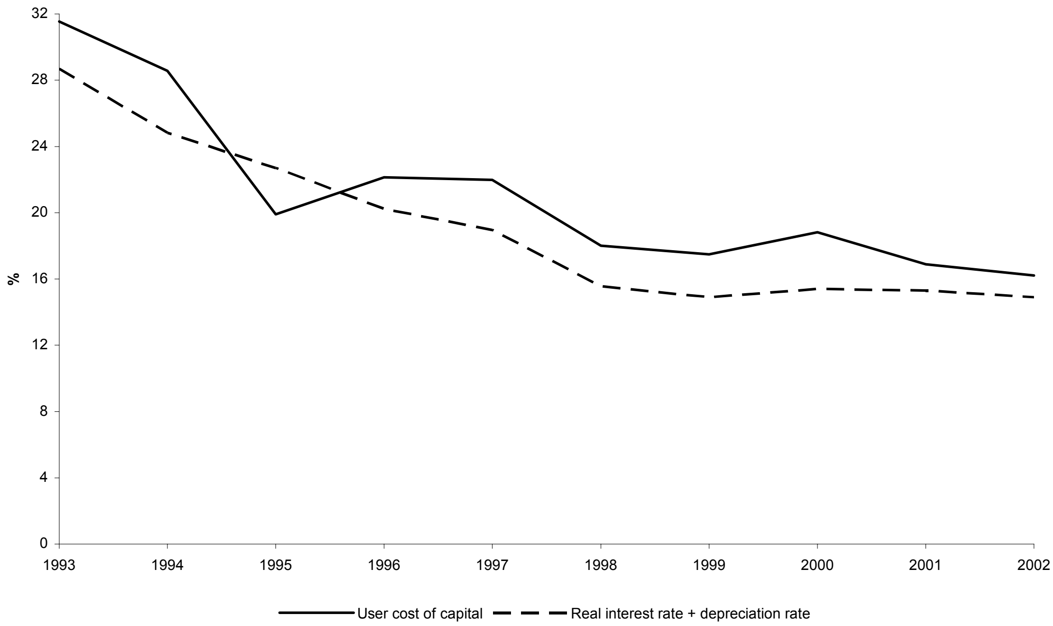
$$(1+r(t))p_i(t) = p_k(t) + (1-\delta)p_i(t),$$

or

$$p_k(t) = (r(t) - (p_i(t) - p_i(t-1))/p_i(t-1))p_i(t-1) + \delta p_i(t),$$

where $p_i(t)$ denotes the investment price at time t. We take the lending rate for long-term loans of capital assets as the relevant interest rate for capital[39]. As the price of capital goods we take the implicit deflator for gross fixed capital formation from the National Accounts. Using a depreciation rate of 0.075 as before, we can calculate the nominal user cost of capital[40]. However, capital is accumulated until the marginal product of capital equals the nominal user cost of capital over the price of output. Figure 8 plots the 'real' user cost of capital, the nominal user cost of capital deflated by the GDP deflator.

Figure 8: User cost of capital



Source: Own calculations using data from SORS and Bank of Slovenia Data.

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[38] Typically, the price of capital would also include taxes and subsidies related to capital accumulation. For example, an investment subsidy would lower the user cost of capital, whereas taxes on land (which we also count as capital) would raise the price of capital, *ceteris paribus*. We ignore these subsidies and taxes in our analysis.

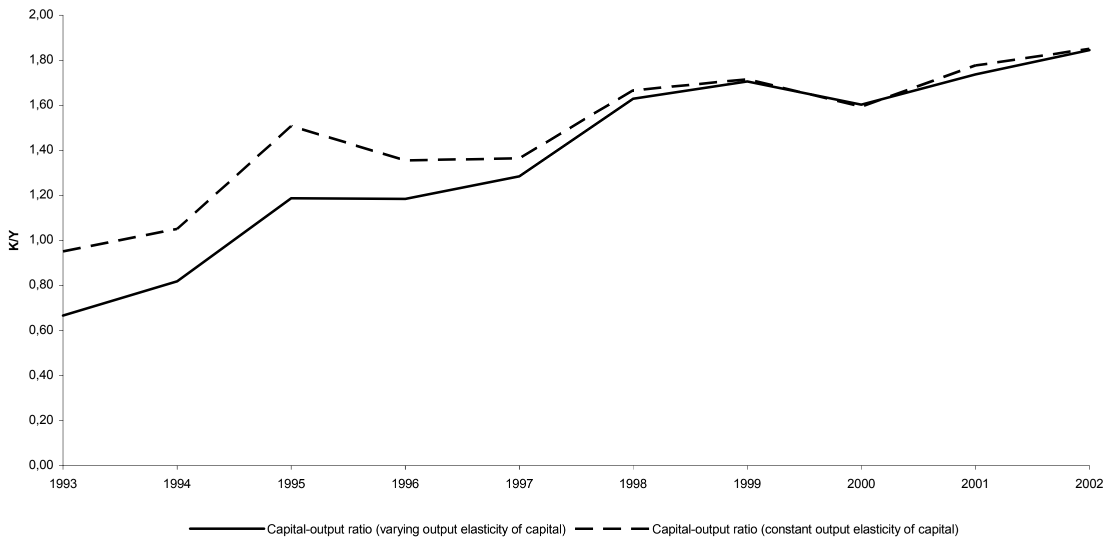
[39] See Table 2.4.1 in the Monthly Bulletin of the Bank of Slovenia.

[40] We assume that individuals have perfect foresight regarding investment prices. We could try to model investment price expectations with an ARIMA specification. However, substantial swings in inflation rates (with annual inflation rising up to 1000+%!) probably imply that there is little to gain from this approach.

Figure 8 suggests a substantial fall in the user cost of capital over the period 1993-2002, reflecting the net effect of a fall in interest rates and inflation in investment priceS[41]. Indeed, there was a substantial drop in real interest rates, due to *e.g.* a declining risk premium or opening up of financial markets. The user cost drops from 0.32 in 1993 to 0.16 in 2002.

Finally, assuming that our constructed series for the capital income share and the user cost of capital are correct, and assuming that capital is paid its marginal product, Figure 9 shows the capital-output ratio implied by the optimality condition for a Cobb-Douglas production function (*i.e.* the capital income share over the user cost of capital).

Figure 9: Capital stock using the marginal productivity condition



Source: Own calculations.

Using either the actual capital income shares over the period 1993-2002 for the elasticity of output with respect to capital, or assuming a constant elasticity of output with respect to capital of 0.3, we find a dramatic rise in the capital-output ratio – from 0.67 in 1993 to 1.85 in 2002 using the former, and from 0.95 in 1993 to 1.85 in 2002 using the latter, see Figure 9. The end values are perhaps not too far from the series in the previous subsection, 2.14, the starting values are much lower though. Even the capital series from the optimality condition using a constant elasticity of output with respect to capital of 0.3 suggests an annual growth in the capital-output ratio of 8% over the period 1993-2002. This seems unrealistic. The results are probably more informative about the difficulties of determining the elasticity of output with respect to capital and calculating the user cost of capital in the rather volatile early 1990s, than about the growth in capital.

[41] The user cost of capital is close to but not exactly the same as the sum of the real interest rate and the depreciation rate used in Mrkaic (2002) and Bovha Padilla and Padilla Mayer (2002), see also Figure 8. The difference is due to a difference in the inflation rate implicit in the user cost of capital, derived from investment prices, and the inflation used by the Bank of Slovenia to calculate the real interest rate, derived from consumer prices.

2.4.3. Comparison with other studies

The perpetual inventory method suggests an annual growth of the capital stock of 6.8% over the period 1993-2002. The optimality condition suggests a much higher growth rate, but the marginal product and the marginal cost of capital are rather hard to determine in the early years following the transition. Below we therefore use the capital stock series from the perpetual inventory method. Supporting 'evidence' comes from capital series constructed for Slovenia by other authors.

Bovha Padilla and Padilla Mayer (2002) obtain a value for the capital-output ratio of 1.5 in 1992, their base year. Our capital series has 1.7 in 1992, somewhat higher. They use the optimality condition to determine this initial capital-output ratio. As we saw above, this produces a relatively low capital-output ratio in the early 1990s. Over the period 1992-2000 Bovha and Padilla (2002) calculate a much lower growth in capital of 1.1% per year, compared to 6.2% in our series. The low growth in Bovha Padilla and Paddila and Mayer (2002) is a bit puzzling given that their initial capital stock is lower whereas they use the same national accounts for subsequent investments.

In preliminary work Mićković and Vasle (2004) calculate a capital-output ratio of 1.43 in 1996, compared to 1.73 in our series. For the period 1992-2002 they further calculate an average annual growth of capital of 6.0%, compared to 6.4% in our series. Below we are mostly interested in the growth rate of capital, which is quite similar.

Doyle *et al.* (2001) obtain a value for the capital-output ratio of 2.11 in 1996, compared to 1.73 in our series. They further calculate an average annual growth in capital over the period 1992-2002 of 4.1%, compared to 6.4% in our series. Their growth rate is quite a bit lower. This is likely to be due to their relatively high starting value. Their capital series starts in 1985, where they assume that the capital-output ratio in Slovenia was the same as in Hungary. This may be too favourable. A growth of 4.1% implies, for example, that there was virtually no capital-deepening over this period. This does not seem to accord with the decline in the user cost of capital over the period 1992-2002[42].

Finally, Piatkowski (2003) obtains a value of 2.28 for the capital-output ratio in 1996, compared to 1.73 in our series. For the period 1995-2000 he finds an average annual growth of capital of 5.3%, compared to 7.5% in our series. Perhaps the difference is due to the different data sources used. We use national accounts of Slovenia directly, Piatkowski (2003) uses them indirectly (investment series are taken from the World Development Indicators, 2003). Another difference is the assumed drop in the capital stock during the late 1980s/early 1990s. Piatkowski (2003) assumes a one-off drop of 25%, we raise the depreciation rate by 7.5% over a five year period, a cumulated additional drop in capital of 32%.

Intermezzo: **Substitutability between capital and labour**

In the next section we consider the individual contributions to GDP growth of the inputs considered above. However, we first take a detour to consider the functional form of the

[42] Furthermore, the share of gross fixed capital formation in GDP in real terms was on average 24% in Slovenia over the period 1993-2002, compared to just 20% in the EU-15 (source: Eurostat, 30-04-2004). This also suggests capital deepening in Slovenia, given that we do not expect Slovenia to have started with a higher capital-output ratio than the EU-15 average in 1993.

aggregate production function. This will have some relevance for the growth accounting exercise below, but is mostly relevant for the subsequent projections for the future.

Suppose that aggregate output *Y(t)* at time *t* is given by the CES-function

$$Y(t) = A_Y(t)\left(\beta(A_N(t)N(t))^\gamma + (1-\beta)(A_K(t)K(t))^\gamma\right)^{\frac{1}{\gamma}},$$

where $A_Y(t)$, $A_N(t)$ and $A_K(t)$ denotes neutral, (effective) labour and capital augmenting progress respectively, *N(t)* and *K(t)* denote (effective) labour and capital, β and γ a parameter where γ determines the elasticity of substitution between labour and capital $\eta \equiv \gamma/(\gamma-1)$. In the analysis below we are mostly interested in whether γ differs significantly different from 0, in which case the CES-production function above reduces to the more convenient Cobb-Douglas function (see *e.g.* Barro and Sala-i-Martin, 1998)

$$Y(t) = A_Y(t)(A_N(t)N(t))^\beta (A_K(t)K(t))^{1-\beta}.$$

Cost minimisation given labour costs and the user cost of capital gives expressions for labour and capital demand. Unfortunately, the capital demand equation gave poor results. This is likely to be the result of the user cost series, in which we do not have great faith, in particular at the beginning of the series (see above). Therefore, we focus on the substitution elasticity implied by the estimated labour demand equation.

Denote average labour costs by *wc(t)*[43]. Furthermore, suppose that $A_Y(t)$ and $A_N(t)$ are of the form $A_x(0)(1+g_x)^t$ with g_x sufficiently small so that $log(1+g_x) \approx g_x$. Starting with the CES-production function above, cost minimisation gives the following relation between the demand for (effective) labour and labour costs[44].

$$\log(wc(t)) = c' + \gamma(g_Y + g_N)t + (\gamma - 1)\log(N(t)/Y(t)) + \varepsilon_t',$$

where $c' \equiv log(\beta(A_Y(0)A_N(0))^\gamma)$, g_Y and g_N denote the growth rate in neutral and labour augmenting technological change, and ε_t' denotes an (identically and independently distributed) error term.

The estimation results are given in Table 2. For comparison, Hamermesh (1993) suggests a reasonable guess for the substitution elasticity between labour and capital is about –1, or γ=0 (the Cobb-Douglas case). When we use employment (in FTE) for the period 1993-2002, we find a value for γ of -0.06, very close to the Cobb-Douglas case (indeed the estimate does not differ significantly from –1(γ=0). When we use the labour composite with employment (in FTE) multiplied by the CES-weighted human capital index of low-

[43] For 1995-2002 we take labour costs per employee of rapid report no. 112 of the SORS. For 1993-1994 and 2001-2002 we calculate labour costs using compensation of employees in the National Accounts plus ‘employers’ payroll taxes’ (introduced in 1994) and taking the corresponding number of employees of the national accounts. The two series are very close in 1995 and 2000 (in both years the difference is less than 1 percent).

[44] We rewrite the first-order condition to labour costs, believing that it is in fact labour that is exogenous and wages that are endogenous.

and high-skilled workers (our preferred series for the human capital index, see above), we again do not reject that $\gamma=0$[45].

Table 2: Substitutability between labor and capital

Estimated parameter	Yg	Y-1	R^2	Durbin-Watson
Using employment	-0.011 (0.018)	-1.062 (0.472)	0.98	1.10
Using the labor composite	0.009 (0.006)	-0.915 (0.246)	0.99	1.33

Note: Standard errors in parentheses; estimation period: 1993-2002.

In the regression with employment as the explanatory variable we find an insignificant negative trend, in the regression with the labour composite as an explanatory variable we find a small positive trend. Note that when γ is indeed 0, we have to be careful with the interpretation of this trend, as g_Y and g_N multiply with γ. What then could the trend represent? One reason why we might expect a negative trend is an issue pursued in Jongen (2004b). There we argue that explaining the rise in the labour income share with changes in the capital-output ratio and the substitutability between labour and capital would require unrealistic changes in the capital-output ratio and/or the substitution elasticity. A more natural explanation for the rise in the labour income share in the late 1980s/early 1990s and the subsequent drop is that labour was able to claim more than its marginal product initially, which was followed by a correction in the subsequent period[46]. The estimation period considered above deals with the 'subsequent period' when wages moved back to the marginal product of labour again. Does this not affect the estimation results for the substitution elasticity? Not necessarily, as long as only the intercept and the trend are affected. Another way to reconcile a trend, in this case negative or positive, with a Cobb-Douglas substitution elasticity would be to assume structural changes that led to a change in the elasticity of output with respect to labour and capital. It is often argued that production in socialist economies favoured manufacturing over services. During the transition some of this imbalance with market economies was restored. This could be another explanation for the trend[47].

One should be careful putting any great store in these estimates, however. Consider for example the estimation with the (log of the) employment-output ratio. Although we do not have enough observations to formally test it, an analysis of the available observations suggests that the series are not stationary in the level (and perhaps the first differences). Hence, the estimates might be spurious (consider also the high R^2 and the relatively low Durbin-Watson statistic). However, the residuals of the estimation of labour costs on the employment-output ratio appear to be stationary. Hence, we do not reject that the series are cointegrated (details available on request). What do we make of this? When we consider

[45] One issue is a potential correlation between the explanatory variable and the error term. Estimating the relations with 'two stage least squares', using lagged explanatory variables as instruments, lowers the estimate of γ to -0.36 in the estimation using employment and raises the estimate of γ to 0.44 in the estimation using the labour composite. None of these estimates for γ differs significantly from 0 though.

[46] Labour derived its power to move off the labour demand curve in the medium run from strict firing legislation.

[47] We are trying to get away with murder here.

the question of whether we reject the null hypothesis that an aggregate production function with capital and labour can be approximated by a Cobb-Douglas production function, we do not. In the absence of evidence to the contrary, we therefore proceed on the assumption that the aggregate production function can be approximated by a Cobb-Douglas function of (effective) labour and capital.

3. GROWTH ACCOUNTING

Using the inputs constructed and analysed in Section 2 we can now use growth accounting to determine the main determinants of output growth. Indeed, for a factor to be important in past growth it must have had substantial growth itself *and* be relatively important for production. Furthermore, using growth accounting we can determine the growth in total factor productivity (TFP), the residual.

For growth accounting we do not need to know the exact form of the production function, although it is convenient when it has constant returns to scale and factors are paid their marginal products (see Barro, 1998, for an excellent overview) which we shall assume below. Suppose that output is a function of total factor productivity, the labour composite and capital

$$Y(t) = f(A(t), N^e(t), K(t)).$$

Taking the derivative with respect to time, and dividing by output we have

$$\overset{\circ}{Y}(t)/Y(t) = f'_A(t)A(t)/Y(t)\,\overset{\circ}{A}(t)/A(t) + .f'_{N^e}(t)N^e(t)/Y(t)\,\overset{\circ}{N^e}(t)/N^e(t) + f'_K(t)K(t)/Y(t)\,\overset{\circ}{K}(t)/K(t).$$

Next assume that technological change is neutral so that $f'_A(t)A(t)/Y(t)$ is 1[48], that labour is paid its marginal product so that $f'_N(t)N(t)/Y(t)$ equals the labour income share in output $lis(t)$ and that $f(.)$ has constant returns to scale and capital is also paid its marginal product so that $f'_K(t)K(t)/Y(t)$ is 1-$lis(t)$ (by Euler's Rule which tells us that $f'_N(t)N(t)+f'_K(t)K(t) = f(.)$ when f has constant returns to scale), we have

$$\overset{\circ}{A}(t)/A(t) = \overset{\circ}{Y}(t)/Y(t) - lis(t)\,\overset{\circ}{N^e}(t)/N^e(t) - (1-lis(t))\,\overset{\circ}{K}(t)/K(t),$$

once we rewrite the accounting relation to the residual TFP growth. We then use the following discrete time approximation for this relation (to take into account that the 'weights', *i.e.* the labour income share, may change from one discrete point in time to the next, see Barro and Sala-i-Martin, 1998, p. 347)[49]

$$\log(A(t)/A(t-1)) = \log(Y(t)/Y(t-1)) - ((lis(t)+lis(t-1))/2)(\log(N^e(t)/N^e(t-1)) +$$
$$(((1-lis(t)) + (1-lis(t-1))/2)\log(K(t)/K(t-1)).$$

48 A very similar expression results if we assume (only) labour augmenting technological change.

49 The discrete time approximation is only exact for the translog production function, see Diewert (1976).

Table 3 gives the resulting contribution of labour, human capital, physical capital and the residual TFP in GDP growth over the period 1993-2002 for different series for human and physical capital. All series use employment in FTE for 'raw' labour, which is multiplied with the respective human capital index series. Furthermore, we use a constant of 0.7 rather than the actual labour income share for all series, assuming that the labour income share was not a very good indicator of the elasticity of output with respect to labour (and its complement for capital in the early 1990s). As already noted above, in Jongen (2004b) we show that the movements in the labour income share are not compatible with realistic assumptions about the changes in the capital-output ratio and the substitution elasticity between (effective) labour and capital over this period. Using the actual labour income shares for the elasticity of output with respect to labour (and indirectly for capital) hardly affects the numerical, and none of the qualitative, results. Capital growth was relatively small at the beginning, when its income share was also relatively low.

Table 3: Growth accounting, in %, 1993-2002

Contribution by	**Labor**	**Human Capital**	**Physical Capital**	**TFP**	**GDP**
Series 1[1]	0.1	1.1	2.0	0.8	4.1
Series 2 (1993-2001)[2]	0.2	1.2	2.0	0.8	4.2
Series 3[3]	0.1	0.3	2.0	1.6	4.1
Series 4[4]	0.1	1.1	1.2	1.6	4.1
Series 5[3]	0.1	0.0	2.0	1.9	4.1

Notes:
1 Series 1 uses employment in FTE, the CES-composite of low- and high-skilled labor for the human capital index and the preferred capital series using the perpetual inventory method.
2 Series 2 uses employment in FTE, average wages of workers relative to the wages of the unskilled for the human capital index and the preferred capital series using the perpetual inventory method. Note that this series runs only until 2001.
3 Series 3 uses employment in FTE, the Hall and Jones (1999) transformation of average years of schooling for the human capital index and the preferred capital series using the perpetual inventory method.
4 Series 4 uses employment in FTE, the CES-composite of low- and high-skilled labor for the human capital index and growth in capital equal to the growth in output.
5 Series 5 uses employment in FTE, ignores the increase in human capital (ends up in TFP) and the preferred capital series using the perpetual inventory method.

Series 1 uses the CES-composite of low- and high-skilled labour for the human capital index and the capital series from the perpetual inventory method, our preferred series for both variables. We find that capital was the most important driving force behind the high GDP growth in this period, although its 'weight' of 0.3 limits its contribution (remember that our capital series had 6.8% growth in this period). Second place is for human capital. This is mostly due to the skill-biased technological change incorporated in this human capital index. Third is TFP, while employment growth made almost no contribution to output growth.

Series 2 uses average wages relative to the wages of the unskilled for human capital, as well as our preferred capital series. In this case, the contributions of the various factors are about the same. Note that this human capital series also includes skill-biased technological change.

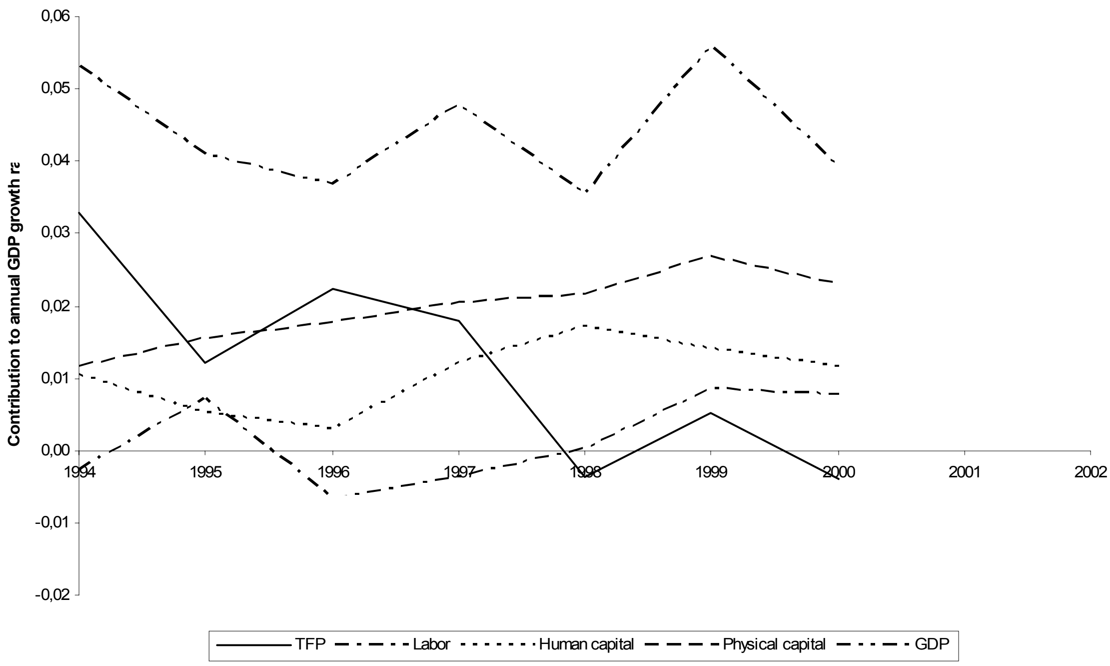
Series 3 uses average years of schooling for human capital, and our preferred capital series. In this case human capital makes a smaller contribution to GDP growth, and hence more is left for TFP. Physical capital accumulation is still the most important contributor to GDP growth though.

Series 4 and 5 consider two further alternatives. In Series 4 we assume there was no capital deepening, *i.e.* the capital-output ratio remained unchanged. In this case, TFP becomes the main contributor and physical capital accumulation and human capital (including skill-biased technological change) are about equally important for past GDP growth. Series 5 considers TFP growth when we abstract from human capital accumulation (for completeness, as many (older) growth accounting studies do not consider human capital). In this case, the 'contribution' of the residual TFP growth is almost the same as the contribution of physical capital growth.

The decompositions above suggest that physical capital accumulation was the most important contributor to growth (the fall in the user cost of capital and perhaps a decline in the capital-output ratio in the late 1980s make it likely that capital grew faster than output over the period 1993-2002), and human capital was second (provided that we incorporate skill-biased technological change in the human capital index).

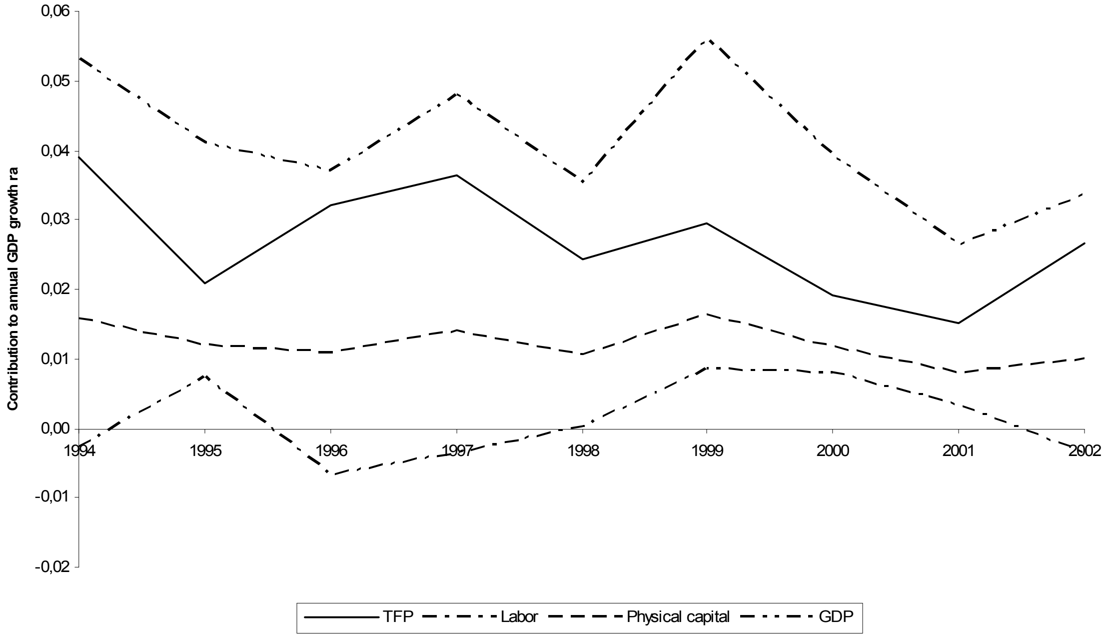
The time pattern of growth in TFP over the period 1993-2002 is rather worrisome. Figure 10 gives the annual contribution to GDP growth over the period 1993-2002 using the preferred series for human and physical capital. Figure 11 gives a 'counterfactual' where we assume there was no capital deepening and no growth in human capital.

Figure 10: Contribution to GDP growth over time, preferred series



Source: Own calculations using growth accounting.

Figure 11: Contribution to GDP growth over time, no physical capital deepending and no human capital growth



Source: Own calculations using counterfactual growth accounting.

GDP growth slows down at the end of the period, whereas physical capital growth remains high and human capital growth picks up. Although the decline in TFP may be largely cyclical, Figure 10 does suggest there is a downward trend in TFP growth over the period in consideration. This is in line with the findings of Mrkaic (2002). Only in the extreme case where we assume that there was no capital deepening and no human capital growth does it become hard to discern a downward trend in TFP growth, see Figure 11.

4. BASE PROJECTION FOR THE PERIOD 2002-2013

After considering the determinants of GDP growth in the past we now turn to the determinants of GDP growth in the future. Using an educated guess for the growth of inputs in the future we make a projection for future GDP growth[50]. We focus on the period up to 2013, the end of the period under consideration in the new strategy for the Slovenian government.

[50] Some would refer to this as ‘potential GDP growth’, because we do not consider the role of the business cycle. However, it would be hard to predict the state of the business cycle in 2013 relative to 2002. Further, over a sufficiently long period of time, business cycle swings in output are relatively small compared to the cumulated growth in GDP.

4.1. Organising framework

In the *Intermezzo* above we concluded that we do not reject the Cobb-Douglas function for aggregate output. Hence, we use the following functional form for output

$$Y(t) = A(t)(HC(t)N(t))^{\beta}(K(t))^{1-\beta},$$

where *N(t)* denotes 'raw' labour and *HC(t)* denotes the human capital index. We focus on a projection for the *average* annual growth rate for the inputs over the period 2002-2013. Hence, we abstract from year-to-year changes in projected growth rates. Indeed, projected annual growth rates are more likely to be off than the average up to 2013. This method implies, however, that our average growth rates will not fall over time even if, for example, we expect the growth rate of capital to be higher in the beginning than the end. This is only a problem if we wish to extend the projection beyond 2013 however.

Using the Cobb-Douglas function we do not have a problem with 'weights' in calculating future growth, and output growth is an additive expression of the growth in the respective inputs

$$g_y = g_A + \beta g_{HC} + \beta g_N + (1-\beta)g_K,$$

where g_x denotes the growth rate of x. We develop this expression a little further because it will be useful to introduce a help variable for the capital-output ratio $\varphi(t) \equiv K(t)/Y(t)$. Substituting $\varphi(t)Y(t)$ for $K(t)$ in the production function, taking all expressions for $Y(t)$ to the left hand side and then taking the derivative to time we get an alternative expression for the growth rate of output

$$g_y = (1/\beta)g_A + g_{HC} + g_N + ((1-\beta)/\beta)g_{\varphi},$$

where we use the growth in the capital-output ratio rather than the growth in capital. The motivation for this is that the capital-output ratio is typically assumed to tend to a constant along the balanced growth path of market economies (one of Kaldor's (Kaldor, 1963) infamous stylised facts, see also Barro and Sala-i-Martin, 1998). The expression above takes this into account. In particular, higher growth in TFP or effective labour also leads to higher capital growth, to keep the capital-output ratio constant. In addition, we can separate these effects from the projected further capital deepening in the Slovenian economy (see below).

4.2. Projection for growth in employment

For the growth in employment and education we take the 'trend' projection of Kraigher (2004). For employment we use the projected growth rate of employment in persons as a proxy for the projected growth rate of employment in full-time equivalents[51]. Kraigher

[51] We further do not consider changes in the average number of working hours per full-time equivalent. Our past employment series also did not take this into account. Below we extrapolate TFP growth from the past into the future, as the residual this implicitly takes into account any change in projected average working hours for a worker that works full-time (and assuming there will be no change in the past trend). According to sources at the IMAD, the average number of working hours for a full-time equivalent per week fell from 43.9 in 1993 to 41.5 in 2002.

(2004) projects the population to fall, by 3,800 people between 2002 and 2013, an annual decline of 0.02%. The gross participation rate is expected to increase slightly, from 67.8% to 68.3%. This is the net effect of an ageing working population (reducing gross participation) and the higher participation of workers aged 25 and over, in particular by workers aged 55-64. The overall result is a drop in gross participation in persons by 6,000. Regarding net participation however, Kraigher (2004) projects a further drop in the unemployment rate from 6.4% in 2002 to 4.5% in 2013, due to demographic factors (older workers have lower unemployment rates than younger workers). As a result, employment grows by 12,200 persons over the period 2002-2013. The corresponding annual growth rate over the period 2002-2013 is 0.12%. As in the period 2002-2013, employment growth is not projected to be one of the main driving forces of GDP growth.

4.3. Projections for growth in human capital

We consider projections for the three human capital indices of Section 2.3: i) average years of schooling; ii) average wages relative to wages of the least skilled; and iii) the CES-weighted composite of low- and high-skilled workers.

In the 'trend' scenario of Kraigher (2004), the average years of schooling rises from 11.6 years to 12.4 years. The growth rate in the corresponding Hall and (1999) transformation is 0.5%, 0.1% higher than in the period 1993-2002 (on average).

Kraigher (2004) also has a projection for the shares of the various types of education in Slovenia. Furthermore, we have the growth in wages relative to the unskilled over the period 1993-2001 from Table 13.5 of SORS (2003). We use the growth in wages relative to the unskilled to calculate an index for 'skill-biased technological change' per type of education and then extrapolate these to the future. Combining the resulting projected wages per education type with the projected shares of Kraigher (2004), we come to a projection of the average wage relative to the least skilled. This human capital index grows at an annual rate of 0.025 (see the Excel file mentioned in Footnote 1 for details). This is significantly higher than in the past (0.015), due to the projected increase in highly educated workers combined with skill-biased technological change for higher educated workers.

Finally, we consider the projected growth in the CES-weighted composite of low- and high-skilled labour. In the 'trend' scenario, Kraigher (2004) projects the share of tertiary-educated workers to rise from 18.4% in 2002 to 28.7% in 2013. Assuming that skill-biased technological growth for individuals with a tertiary education will continue at an annual rate of 0.017[52], the projected annual growth in this human capital index is 2.3%. Hence, also according to this indicator we project higher growth in the human capital index in the future than in the previous period (1.6% over the period 1993-2002). Without a rise in the share of the tertiary educated, the index would still grow at 1.6% per year on average over the period 2002-2013 due to skill-biased technological change.

[52] And assuming that $\gamma = 0.33$, see Section 2.3.3.

4.4. Projection for growth in physical capital

Two key factors play a potential role in the future regarding capital accumulation: i) has the capital-output ratio in Slovenia recovered from the transition?; and ii) do we expect a further fall in the user cost of capital in Slovenia?

In Section 2.4 we calculated that the capital-output ratio in Slovenia in 2002 is somewhere in the order of 2.14, coming from around 1.70 in 1993. Jongen (2004b) compares this capital-output ratio with those reported by Hall and Jones (1999) for EU-15 countries, whose weighted average is 2.4 (using population of Groningen Growth and Development Centre (2004) as weights). Hence, provided that the long-run capital-output ratio is somewhere in the vicinity of the EU-15 average, the capital-output ratio in Slovenia has largely recovered from the transition, but there is still some room for further capital deepening left.

The real interest rate tells a similar story. The real interest rate was still relatively high in 2002, which suggests that the user cost of capital remained relatively high. In 2002 the real interest rate on long-term capital loans was on average 7.4%, compared to 3.4% in the euro-zone[53]. By December 2003 the real interest rate on long-term capital loans had already fallen to 5.2% in Slovenia[54].

Let us suppose that the capital-output ratio will converge to the EU-15 average of Hall and Jones (1999), 2.4, over the period 2002-2013. Starting with a capital-output ratio of 2.14 in 2002, I calculate an average annual growth in the capital-output ratio of (exp(1/11*log (2.40/2.14)) –1) * 100% = 1.05% to reach 2.40 by 2013.

4.5. Projection for total factor productivity

Finally, what do we expect for the growth of total factor productivity? Over the period 1993-2002 we found that, when using the CES-weighted series for human capital, the ‘average wages relative to the wages of the unskilled’ series and average years of schooling led to respective growth in TFP of 0.8, 0.8 and 1.6%. However, from Figure 10 we concluded that 1994 might be an outlier. Excluding 1994 we find growth in TFP of 0.5, 0.3 and 1.3%, respectively. This suggests that extrapolating TFP growth from the past would be too favourable. But then again, the low TFP growth in the last years is likely to partly reflect the business cycle downturn. Furthermore, increased trade with the EU may speed up convergence with the EU (see *e.g.* Ben-David, 2000). Indeed, the international growth accounting exercise in Jongen (2004a) suggests there is still a substantial remaining gap in TFP relative to the EU-25 on average. Based on these considerations we prefer to use 0.5% of TFP growth in the future when using the CES-weighted human capital index, 0.3% when using the average wages human capital index, and 1.3% when using average years of schooling. Hence, I exclude the ‘outlier’ 1994, but do not assume a downward trend. We consider the impact of lower and higher TFP growth in the sensitivity analysis below.

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[53] Source: Eurostat (30-09-2004). We subtracted the average annual rate of change in the harmonized price index of the euro-zone from the average nominal interest rate on long-term capital loans.

[54] Source: Bank of Slovenia (www.bsi.si, 30-04-2004).

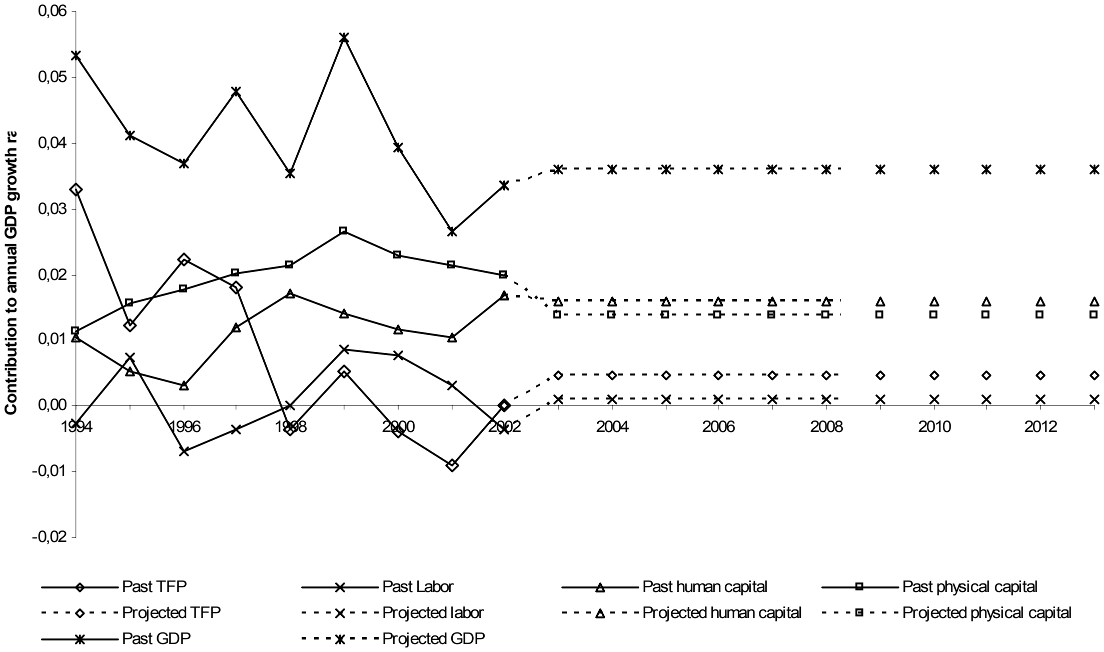
4.6. Base projection for output

Using the projected inputs above we make a projection for GDP growth. For the period 2002-2013 we project an average annual growth in labour of 0.12%, in the capital-output ratio of 1.05% (*i.e.* we project capital to grow 1.05% faster than GDP annually), and in TFP of 0.5% when we use the CES-weighted human capital series, 0.3% when we use the average wages relative to the wages of the least-skilled human capital series, and 1.3% when we use average years of schooling for human capital. Furthermore, we expect the CES-weighted index of human capital to grow at 2.3% per year, the average wages relative to the wages of the least skilled to grow at 2.5% per year and the average years of schooling index to grow at 0.5% per year. We assume that the production function is Cobb-Douglas with constant returns to scale and the elasticity of output with respect to labour is 0.7.

Using the CES-weighted composite of low- and high-skilled labour for the human capital index, we then project an average annual GDP growth of 3.6% over the period 2002-2013. Using the average wage relative to the least skilled gives 3.5% and using average years of schooling gives 2.9%. In the last case, the drop in capital accumulation is only partly compensated for by the higher human capital growth.

Hence, we project GDP growth to slow down somewhat compared to the period 1993-2002. This is the result of lower projected capital deepening in the future than in the past, this drop dominates the projected increase in the growth rate of human capital. The projected growth rates are still impressive though. Using our preferred CES-weighted human capital series, Figure 12 puts the contributions of the various factors in projected GDP growth in a historical perspective. Note that the smooth patterns after 2002 are an artefact of transforming year-to-year growth rates up to 2013 into an average annual growth rate for all the inputs. Figure 12 illustrates the reversing roles of human and physical capital accumulation in the past and in the projected future (with human capital including skill-biased technological change).

Figure 12: Growth accounting of past and projected GDP growth



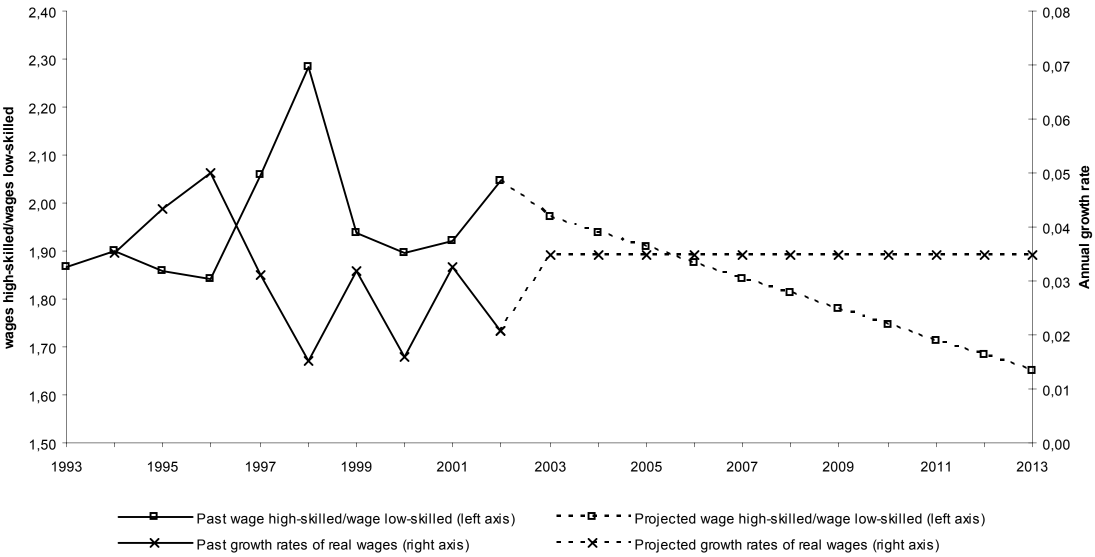
Source: Own calculations using growth accounting.

Figure 13 puts the projection for average real wage growth and the ratio of wages of high- to low-skilled workers into a historical perspective. Over the period 1993-2002 wages grew at 3.1% per year[55], for the future we project wages to grow at 3.5%[56]. Figure 13 further shows that we project a reversal in the trend of high- to low-skilled wages. In the past, skill-biased technological change outpaced the increase in the relative supply of skilled workers. In the future we project that the rise in the growth of high-skilled workers will dominate the effect of skill-biased technological change.

[55] Over the 1993-2002 period, wages grew less than output per worker.

[56] In the Cobb-Douglas case the growth rate of wages is the growth rate of output minus the growth rate of employment.

Figure 13: Projected wages



Source: Own calculations.

Finally, Figure 14 gives a projection of the investment-output ratio (in real terms, both series are expressed in 1995 SIT). We can compute the corresponding projected investment-output ratio from the capital accumulation equation, using the fact that for simplicity we assume growth rates to be constant. Capital accumulation follows from (see Section 2.4.1)

$$K(t) = (1-\delta)K(t-1) + I(t),$$

Rewrite this to investment to obtain

$$I(t) = K(t) - (1-\delta)K(t-1).$$

Noting that capital grows g_φ faster than output we can rewrite this to

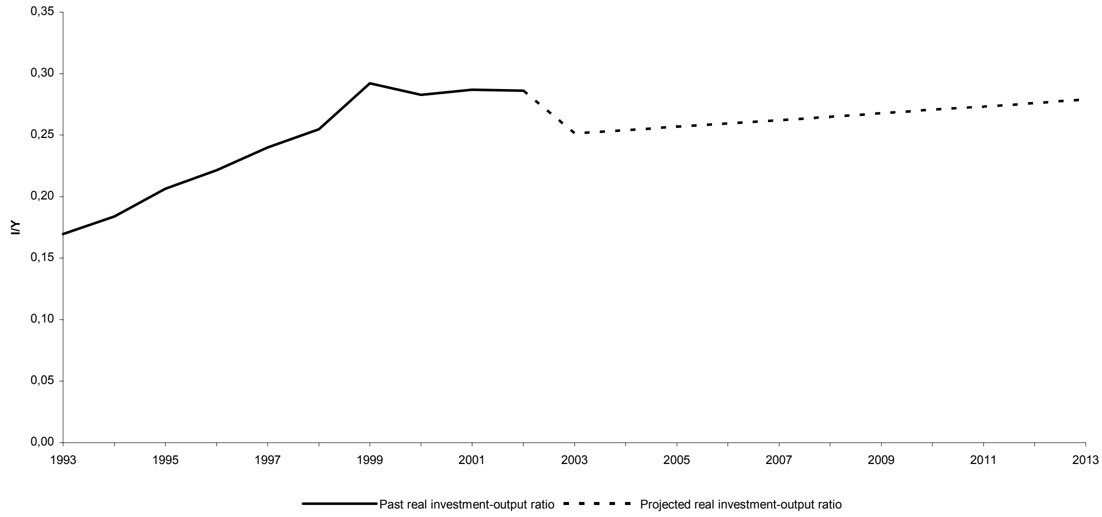
$$I(t) = K(t)(1-(1-\delta)/((1+g_y)(1+g_\varphi))).$$

Dividing by output and noting that $K(t)/Y(t) = K(0)/Y(0)(1+g_\varphi)^t$ we obtain

$$I(t)/Y(t) = K(0)/Y(0)(1+g_\varphi)^t(1-(1-\delta)/((1+g_y)(1+g_\varphi))).$$

Figure 14 plots the resulting series starting with a capital-output ratio of 2.14 in 2002 and a depreciation rate of 0.075. Figure 14 suggests that the real investment-output ratio may fall in the future compared to the recent past (1999-2002). This is the result of a slowdown in capital deepening. Note that the relation above further suggests a mild increase in the investment-output ratio. This is however an artefact of the fact that we assume there will be gradual capital deepening up to 2013. If most of the capital deepening were to take place in the early years, we would obtain a perhaps more realistic flattening-out pattern of the investment rate. Here we are mostly interested in the average increase in the investment-output ratio over the whole period 2002-2013 though.

Figure 14: Investment out-put ratio



Source: Own calculations.

Note: The investment out-put ratio is in real terms (in 1995 SIT).

5. SENSITIVITY ANALYSIS OF BASE PROJECTION[57]

Our base projection with the preferred series for human capital suggests that Slovenian real GDP will grow at about 3.6% per year over the period 2003-2013. In this section, we consider the sensitivity of this projection to some alternative developments in the inputs in the past and future[58]. Furthermore, we also briefly compare our base projection with the projected growth rates in some related studies on Slovenia.

5.1. Sensitivity to alternative developments in the past

We do not consider the sensitivity of the projection to alternative labour and TFP growth in the past. The growth of labour is presumably measured quite accurately, whereas alternative developments in TFP growth would merely reflect alternative developments in the other inputs (it is calculated as a residual). We consider the sensitivity to alternative *future* labour and TFP growth in the next subsection. The focus here then is on alternative developments in human and physical capital in the past.

Regarding human capital we will focus on our preferred series for human capital growth in the past, the CES-composite of low- and high-skilled labour. We first note that for any input that would grow at the same rate in the future as it did in the past, alternative growth rates from the past would have no effect on the base scenario. This is because a change in

[57] The following recent quote of US Defence Secretary Donald Rumsfeld springs to the mind:' ... as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns - the ones we don't know we don't know.' Our sensitivity analysis does not consider the 'unknown unknowns'.

[58] Here we are mostly concerned with the sensitivity of the base projection with respect to alternative 'trend' developments in the past and future. In Jongen (2004a) we consider the impact of some alternative policy scenarios on the base projection.

the growth rate of this input in the past leads to an offsetting change in the growth rate of TFP in the past, and the TFP growth of the past is used to project TFP growth in the future. However, in the base projection the growth rate of human capital is projected to rise from 1.6% over the period 1993-2002, to 2.3% per year over the period 2002-2013. Hence, different paths for past human capital growth will imply different paths for projected real GDP growth. As a reasonable alternative development in human capital in the past let us again consider the estimation results of Table 1. In our preferred series for the human capital index we have 1.7% of skill-biased technological change per year and a substitution elasticity of -1.5 between low- and high-skilled labour. The estimation results in Table 1 suggest a standard deviation of skill-biased technological change of 0.6%. As a lower and upper margin for human capital growth in the past we then calculate the rise in the human capital index with 1.1% and 2.3% of skill-biased technological change, respectively. This results in a lower and upper bound for the annual growth in the human capital index of 1.1% and 2.2% for the period 1993-2002, respectively. This implies a different value for TFP growth in the past and the future. For the past, the TFP growth rate rises and falls to 0.9% and 0.1% for the lower and upper bound of the growth in the human capital index, respectively. For projected GDP growth in the future there are 2 effects. First, there is the effect on TFP, which is the projected effect from the past, a rise or fall of about 0.4%. Second, the expected growth in the human capital index changes. At the lower margin the future growth in the human capital index falls from 2.3% to 1.5%. At the upper margin, the growth in the human capital index rises from 2.3% to 3.2%. Taking into account both the effect on future TFP growth and the future growth in the human capital index, we expect future real GDP growth to lie between 3.4 and 3.9%. Note that a large part of the resulting higher or lower future growth in the human capital index is offset by the opposing change in projected TFP growth.

Next, we consider alternative developments for capital deepening in the past. Our preferred capital series has an average annual growth rate of 6.8% over the period 1993-2002. We have reliable data for real investment over this period. However, we have only limited knowledge of the depreciation of capital, and the level of the capital stock in any given year. This makes past capital growth relatively unreliable. However, given the drop in the user cost of capital it does seem likely that there was some capital deepening (*i.e.* a rise in the capital-output ratio). Let us then take as a lower margin that capital grew at the rate of output, 4.1%, over the period 1993-2002, and let us take the 'symmetric opposite' from our preferred series, 9.5% (=6.8% + (6.8-4.1)%), as the upper margin. How do these lower and higher capital growth rates in the past affect projected growth? Via TFP. With physical capital growth at the lower and upper margin, TFP growth would be 0.8% higher or lower, respectively. Following our base scenario methodology, this would imply that the future growth of real GDP could be 1.1% higher or lower, for the lower and upper margins respectively. Hence, changes in past growth in physical capital have a substantial impact on projected GDP growth. Note that because we assume this has no effect on future capital deepening, there is no offsetting effect on projected capital growth.

5.2. Sensitivity to alternative developments in the future

The growth in labour is expected to fall slightly, from about 0.16% over the period 1993-2002 to about 0.12% over the period 2002-2013. This is mostly due to a fall in the unemployment rate. As an alternative, consider the case where there would be no drop in unemployment[59]. Employment would then fall at an annual rate of -0.06%. This lowers projected output growth to 3.4% per year. However, we may also envisage a higher growth rate of employment due to *e.g.* a higher increase in the participation of the elderly than in the base projection for example[60]. Suppose that we take the symmetric opposite again, where employment would grow at 0.30% per year over the period 2002-2013. This would raise GDP growth to 3.8% over the period 2002-2013.

Regarding human capital, we considered alternative assumptions regarding skill-biased technological change above in the sensitivity analysis regarding developments in the past. Here we concern ourselves with alternative future developments in the share of high-skilled workers. Given the high recent enrolment rates in tertiary education and the projected outflow of relatively low educated workers from the workforce, it seems reasonable to expect a further rise in the share of high-skilled workers. Let us consider a scenario where the growth in the share of tertiary educated workers is 50% lower or higher than in the base scenario. This would result in annual growth in the human capital index of 2.0% and 2.5%, respectively. Note that the change in the growth in the human capital index is not that dramatic since it also captures the unaltered growth in skill-biased technological change. Annual output growth falls and rises to 3.3% and 3.8%, respectively.

Next, consider alternative future scenarios for capital growth. In the base projection we calculate a further capital deepening of 1.05% per year over the period 2002-2013. As an alternative, suppose there will be no further capital deepening or that the substantial capital deepening will continue to some extent into the future, 0.0% and 2.1% for the growth in $K(t)/Y(t)$, respectively. This would lower or increase projected output growth to 3.1% and 4.0%, respectively.

Finally, perhaps the hardest series to project is TFP growth. In the discussion of the base projection we argue that there are good reasons to expect TFP growth in the future to be either higher or lower than in the past. It is hard to put a reasonable margin on this, but suppose that we consider TFP growth to be 50% lower or higher, respectively. This would reduce or increase annual real GDP growth over the period 2002-2013 to 3.2% and 3.9%, respectively.

[59] Assuming no drop in the unemployment *rate* leads to almost the same quantitative results, the change in the gross number of participants is relatively small.

[60] For a more elaborate analysis of the participation rates of the elderly in the future, see Jongen (2004a).

Table 4: Sensitivity analysis projected annual growth in GDP per capita, growth rates in %, 2002-2013

Growth in	Labor	Human Capital	Capital output ratio	TFP	GDP p.c. growth
Slovenia					
base projection	0.1	2.3	1.1	0.5	3.6
alternative developments in the past					
lower human capital growth (-1 sd)	0.1	1.5	1.1	0.9	3.4
higher human capital growth (+1 sd)	0.1	3.2	1.1	0.1	3.9
lower physical capital growth (K/Y constant)	0.1	2.3	1.1	1.3	4.7
higher physical capital growth (K/Y 9.5%)	0.1	2.3	1.1	-0.3	2.4
alternative developments in the future					
no drop in unemployment	-0.1	2.3	1.1	0.5	3.4
higher participation	0.3	2.3	1.1	0.5	3.8
lower human cap. growth (growth in s_h -50%)	0.1	2.0	1.1	0.5	3.3
higher human cap. growth (growth in s_h +50%)	0.1	2.5	1.1	0.5	3.8
lower phys. cap. growth (K/Y constant)	0.1	2.3	0.0	0.5	3.1
higher phys. cap. growth (K/Y 2.1%)	0.1	2.3	2.1	0.5	4.0
lower TFP growth (-50%)	0.1	2.3	1.1	0.3	3.2
higher TFP growth (+50%)	0.1	2.3	1.1	0.8	3.9
EU-25					
Base projection	-	-	-	-	2.3
Lower projected growth	-	-	-	-	2.1
Higher projected growth	-	-	-	-	2.5

Table 4 gives an overview of the results from the sensitivity analysis of projected real GDP growth. For most alternative developments we find that the alternative growth rates move within the band from 3.0% to 4.0%. The notable exception being past physical capital growth, whose uncertain past growth rate cause future output growth to move within the band of 2.4% to 4.7%. A comparison with other studies on past capital growth in Slovenia suggests that, if anything, past capital growth is however more likely to have been lower than higher than our preferred series. Projected output growth would then be more likely to be higher than lower.

5.3. Comparison with other studies

We conclude the sensitivity analysis by briefly considering the projected growth rates of some other studies that deal with future GDP growth in Slovenia.

For an illustrative calculation regarding convergence to the EU (for more on this, see Section 6 below), the Economic Policy Committee (2003) of the EU suggests an annual growth rate for Slovenia of 3.7% from 2004 onwards.

Fisher *et al.* (1998a) suggest a per capita growth rate somewhere between 3.8% (using the 'Levine-Renelt' equation, see the paper for details) and 4.6% (using the 'Barro' equation, see the paper for details) from the mid-1990s onwards. Fisher *et al.* (1998a) come to these growth rates by superimposing the results from cross-country regressions on other countries (not enough data were available at the time for the transition countries) on the impact of variables like education, government expenditures and initial income on subsequent growth rates. In a closely related study, Fisher *et al.* (1998b) somewhat surprisingly come to higher growth rates of 4.6 and 5.3 for per capita growth. These growth rates apply to the period after the mid-1990s. Over the period 1995-2002 the actual per capita growth was 4.0%. Hence, the projection of Fisher *et al.* (1998a) comes surprisingly close. Hence, for this period at least the growth potential in Slovenia seems to be quite well summarised in initial GDP per capita and only a few other conditioning variables. Assuming no big changes in the conditioning variables since 1995, the higher per capita income in 2002 than in 1995 would imply a somewhat lower growth for the period after 2002, in line with our projection.

Following a similar procedure as Fisher *et al.* (1998a,b), but using new growth regressions (using *e.g.* relative income rather than absolute income as a dependent variable)[61], Crafts and Kaiser (2004) come to a projected annual growth rate in GDP per capita of 3.0% to 3.4%[62]. Crafts and Kaiser (2004) further argue that the projections of Fisher *et al.* (1998a,b) are too favourable, in part due to the use of absolute rather than relative income levels, and in part due to the omission of some institutional variables. As shown above, however, at least for the period 1995-2002 the projection of Fisher *et al.* (1998a) was quite accurate for Slovenia.

Finally, following again an essentially similar procedure as in Fisher *et al.* (1998a,b), but now superimposing parameters estimated from data on only Western European economies, Wagner and Hlouskova (2001) come to a growth rate in between 3.0 and 4.6% depending on the scenario used. They report a mean of the scenarios of 3.9%, but this seems to be driven to some extent by the (arbitrary) large share of relatively favourable scenarios.

To summarise, Fisher *et al.* (1998a) predicted per capita growth of around 4% for the period after 1995, which seems pretty accurate up to 2002. The approach of Fisher *et al.* (1998a) would also lead to a somewhat lower growth rate after 2002, as Slovenia has been catching up in income levels since 1995. Fisher *et al.* (1998b) seems too optimistic. Crafts and Kaiser (2004) predict somewhat slower growth after 2002, around 3.2%, whereas Wagner and Hlouskova (2001) predict somewhat higher growth (taking their reported mean of the scenarios) of 3.9%. Overall, we conclude that these studies using a 'Barro regression' type of approach to projected growth lead to a similar picture for future GDP growth in Slovenia as our 'growth accounting' approach, an annual per capita growth rate lying somewhere between 3% and 4%.

6. CATCHING UP WITH THE EU

Finally, we consider convergence with the EU-average (the EU-15 plus the 10 new member states that joined in the wave of 2004) in terms of GDP per capita. Again we focus on the period up to 2013. First, will 3.6% be enough to catch up with the EU average by

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[61] Furthermore, they also have the advantage of hindsight for the 1998-2003 period.

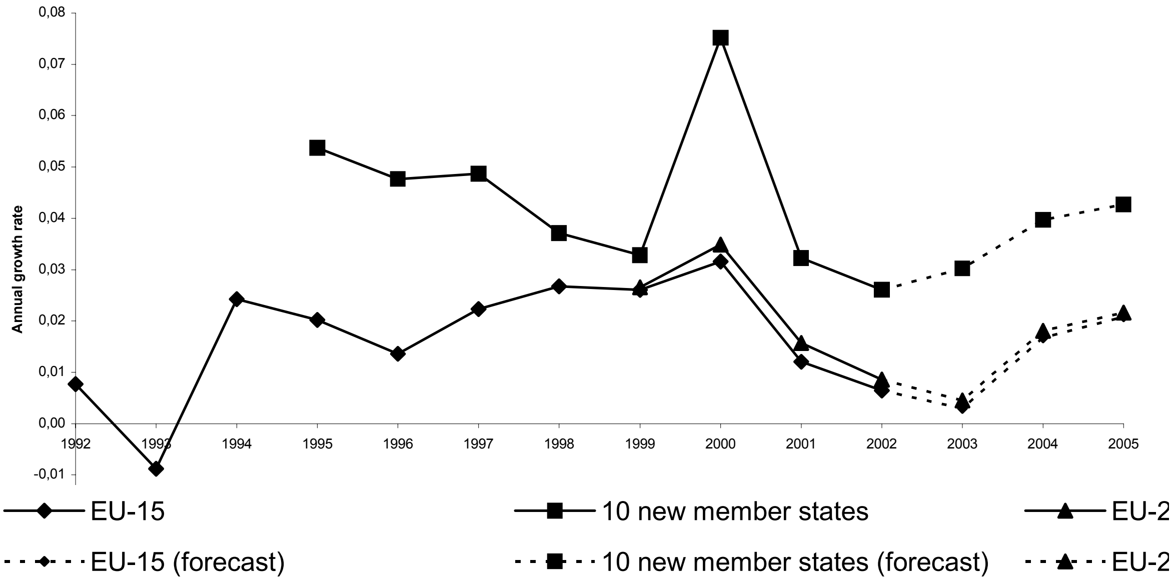
[62] Leaving out the 'outlier' of 1.3 in column (7) in Table 6 of Crafts and Kaiser (2004).

2013[63]? For this we will need to make a projection for the EU growth rate as well. Furthermore, if 3.6% is not enough, what would be the required growth rate for Slovenia to catch up by 2013?

6.1. Base projection EU growth rate

Unfortunately, no official long-run projections or scenarios for real per capita GDP growth in the EU exist, at least not up to 2013. For some back-of-the-envelope calculations for the time it will take for CEECs to catch up with the EU-15, the EPC (2003) used a growth rate of 2.4%. This seems a bit too favourable, however, as we will see below.

Figure 15: Recent growth rates in GDP per capita in EU



Source: Eurostat (01-02-2004), and own calculations.

A detailed projection for the EU along the lines of the projection we made for Slovenia is beyond the scope of this paper. Instead, we will simply extrapolate past EU growth into the future. Figure 15 plots the recent growth rates of GDP per capita in the EU-15 (1992-2002), the 10 new member states that joined in the wave of 2004 (1995-2002), and the 'EU-25' (1999-2002). The data are taken from Eurostat. Figure 15 also gives the forecast for 2003-2005 from Eurostat (in February 2004). The average growth rate of the EU-15 was 1.7% from 1992 to 2002. The average growth rate of the new member states over the shorter period 1995-2002 was substantially higher, 4.4%. The main point of this graph, however, is that the growth rate of the EU-25 is mainly determined by the growth rate of the EU-15, due to its much larger population[64].

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[63] The projected change in the population is so small that we can take the projected percentage change in real GDP as the projected change in real GDP per capita.

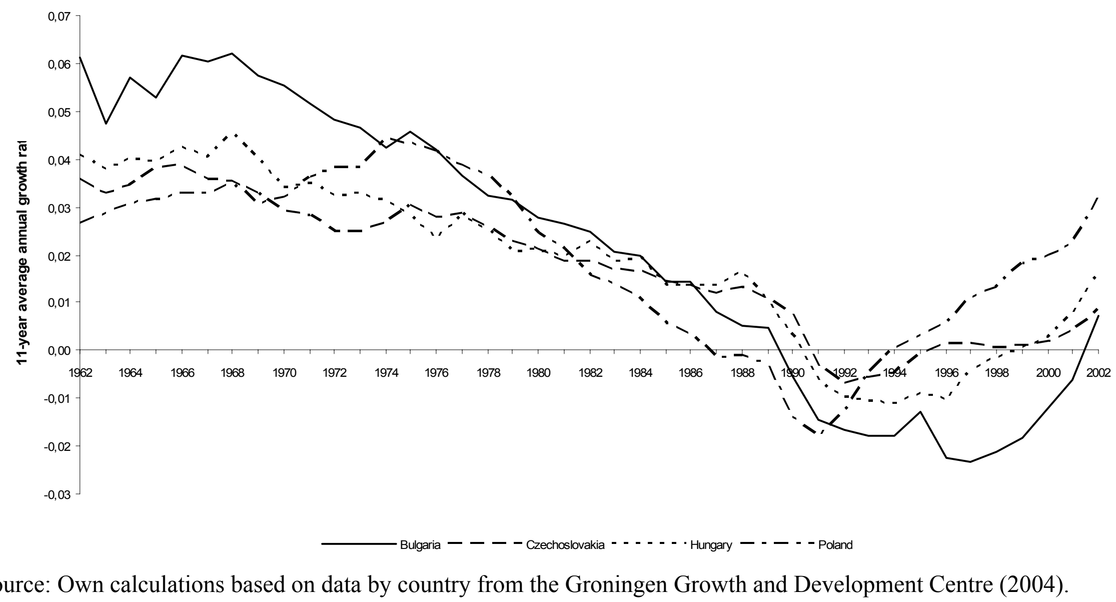
[64] According to Eurostat on 01-01-2003 the population in the 10 new member states was about 74 million, compared to a population of about 380 million in the EU-15.

For an educated guess of growth in the EU-15 we have to take a look at longer data series. Figure 16 plots the 11-year averages for the EU-15, and the US and Japan for the period 1951-2002. We calculate 11-year averages because of the length of the interval we are interested in: 2003-2013. The value for a given 'year' denotes the average growth rate of that year and the 10 years preceding it (hence, 2002 gives the average growth rate for the period 1991-2002).

Figure 16: 11-years average of per capita growth rates, selected OECD countries/regions

Source: Own calculations based on data by country from the Groningen Growth and Development Centre (2004).
Note: The series for the EU-15 exclude data for Germany. We take the 'EU-14' as an indicator of the growth of real GDP over an 11-year period in the EU-15. '1962' is the average growth rate for the period 1951-1962, *etc*.

Figure 17: 11-years average of per capita growth rates, selected CEEC countries/regions



Source: Own calculations based on data by country from the Groningen Growth and Development Centre (2004).
Note: The series for Czechoslovakia are for the sum of the Czech and Slovak Republic before and after the split. '1962' is the average growth rate for the period 1951-1962, *etc*.

For the EU-15, and most other countries (see the US and Japan series), there appears to be a structural break in the growth rate around the beginning of the 1970s (the 'productivity slowdown'). Selecting 1973 as the break point, we calculate an average growth rate of 2.1% over the period 1993-2002. The maximum 11-year average over the period 1973-2002 was 3.4%, which occurred at the beginning of the period, the minimum is 1.8%, which occurs in some subsequent periods.

Figure 17 plots 11-year averages for selected Eastern and Central European countries (we only include countries that have long data series). Figure 17 shows the dramatic decline in the per capita growth rate of real GDP in these countries in the late 1980s/early 1990s[65], and the subsequent rise. Figure 17 indicates that the growth in the CEECs was more volatile than in the EU-15.

Suppose we take the populations of the EU-15 and the 10 new member states in 2002 as weights (380 and 74 million inhabitants, respectively). Suppose that GDP per capita in the EU-15 continues to grow at 2.1% as it did in the period 1973-2002, and suppose that GDP per capita in the 10 new member states grows on average at the same pace as our base projection for Slovenia, 3.6%. We then come to a base projection for future annual growth in GDP per capita in the EU of 2.3%[66].

6.2. Convergence?

If GDP per capita in the EU grows at 2.3% per year over the period 2002-2013, what would be the required growth rate for GDP per capita in Slovenia over this period in order to catch up with the EU average?

In 2002 Slovenia was at 75.5% of average real GDP per capita in the EU-25 (in purchasing power parity (PPP) terms)[67]. Solving for g^* in $(1+g^*)$^11*0.755 = 1 gives $g^* = 0.026$. Hence, to catch up with the EU in terms of GDP per capita by 2013, real GDP per capita in Slovenia has to grow 2.6% faster than in the EU over the period 2002-2013. With a projected growth rate of 2.3% for the EU, this implies that Slovenian per capita growth would have to be 4.9%, 1.3% higher than our base projection.

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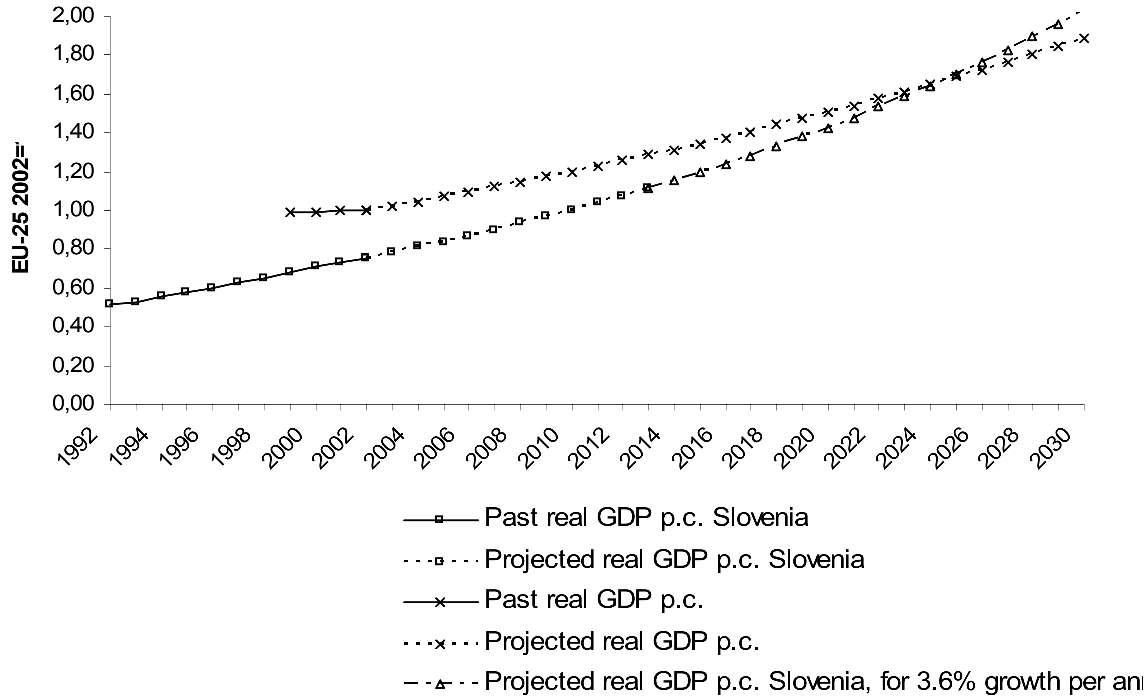
65 Figure 17 also suggests that the Central and Eastern European countries had on average similar or even higher growth rates than the OECD countries of Figure 16 until the 1980s. However, the old data are not very reliable. Informal sources suggest, for example, that the inflation rate was understated so as to overstate the real growth rate.

66 For comparison, CPB Netherlands Bureau for Economic Policy Analysis recently published four scenarios for the future of Europe, see Lejour (2003) and De Mooij and Tang (2003). They distinguish the following scenario's: 'global economy', 'strong Europe', 'regional communities' and 'transatlantic market'. For the 2002-2013 period they find the following average growth rates in real GDP per capita for the EU-15 for these 4 scenarios, respectively: 2.2%, 1.4%, 1,1% and 2.1%. For what they define as Central and Eastern Europe (Poland, Hungary, Czech Republic, Slovakia, Slovenia, Bulgaria, Romania) they find the following real GDP per capita growth rates for the 4 scenarios, respectively: 3.5%, 3.6%, 2.5% and 3.0% (source: personal communication). Using the growth in 'Central and Eastern Europe' as a proxy for the growth in the 10 new member states and assuming that the relative population remains the same as in 2002 (EU-15 380 million, 10 new member states 74 million) we find for the EU-25 the following respective growth rates in GDP per capita over the 2002-2013 period: 2.5%, 1.7%, 1.3% and 2.3%. From this I take it that a value of around 2.3% is not out of line with these scenarios.

67 Source: IMAD.

As an exercise, suppose that we extrapolate the growth in Slovenian and EU real GDP per capita growth of 3.6% and 2.3% beyond 2013, then it would take up to around 2025 before Slovenia catches up with the EU average, see Figure 18. Note that this is presumably still too favourable as we may not expect any further increase in the capital-output ratio beyond 2013, for example. Without capital deepening beyond then, it would take until 2032 before Slovenia would catch up with the EU average[68].

Figure 18: Convergence with the EU?



Source: Own calculations.

As an exercise we may further consider the change in the inputs required in Slovenia to increase real GDP growth by this 1.3% relative to the base scenario. The change required per single input is as follows. TFP growth would have to be 1.3%*0.7 = 0.9% higher than in the base projection[69]. Alternatively, the growth in labour or the human capital index would have to be 1.3% higher. Finally, the capital-output ratio would have to be 1.3%*0.7/0.3 = 3.0% higher over the period 2002-2013 to catch up with the EU-25 average in 2013.

[68] We might also not expect any further labour growth after 2013, but the same probably holds for the EU.

[69] Note that the impact of higher TFP growth on GDP growth gets an additional boost from higher capital growth, to keep the capital-output ratio constant.

6.3. Uncertainty regarding future EU growth

As for Slovenia, we also want to consider some reasonable alternative future scenarios for per capita GDP growth in the EU. The standard deviation of the 11-year averages series for the growth rate of the EU-15 over the period 1973-2002 is 0.13[70]. Supposing that the growth rates of the new member states will remain more volatile[71], a reasonable lower and upper margin for future per capita GDP growth in the EU seems to be 2.1% and 2.5%, respectively. Slovenian GDP growth would then have to be correspondingly lower and higher to catch up with the EU by 2013.

7. CONCLUDING REMARKS

The future for growth in real GDP per capita in Slovenia still looks bright. Over the period 1993-2002 Slovenian GDP per capita grew at the brisk pace of 4.1% per year. The main driving forces appear to have been physical and human capital accumulation. For the future, we project somewhat slower growth, around 3.6% when using our preferred series. Human capital accumulation is projected to pick up but this is dominated by lower projected physical capital deepening.

3.6% growth in real GDP per capita in Slovenia will not be enough to catch up with average real GDP per capita in the EU by 2013. To catch up with the EU average by 2013, growth in GDP per capita in Slovenia would have to be about 4.9% per year. Given the base projection of 3.6%, this seems a rather big leap. However, in Jongen (2004a) we indicate that there is still a lot of room for improvement relative to the EU, in particular in TFP, which leaves much room for still higher growth rates.

We conclude with a cautionary note. The preceding analysis builds on short data series of an economy that has witnessed substantial structural changes over the past decade, and which can be expected to witness more of them in the future. Hence, our findings from the past and projections for the future should be interpreted with perhaps more than the usual levels of care.

[70] In this calculation the early years and the final years will be 'undersampled', as 1973 and 2002 are included only once for example. The standard deviation of the *annual* growth rates is 1.4 over the 1973-2002 period, 1.8 over the 1973-1983 period and 1.2 over the 1992-2002 period (the 'undersampled' periods). We assume that the 'undersampling' of both periods cancels out. Further, with the standard deviation falling over time, we are already taking a relatively wide band.

[71] And assuming that this raises the volatility of the EU growth rate, *i.e.* deviations in growth rates in the EU-15 and the 10 new member states do not move in opposite directions, which seems increasingly likely with the increased trade relations between the EU-15 and the new member states.

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