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Impact of the transition on the TFP in Croatia

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Abstract

In this paper we investigate the impact transition had on the total factor productivity in Croatia. The analyzed data cover the period from 1952 to 2008. Our sample is interesting for several reasons. It includes first estimates of physical capital for Croatia in the pretransition period. In addition to new physical capital series used in the estimation of Croatian TFP, labor has been used in three different forms: as raw labor and as labor corrected with two alternative proxies of human capital. The obtained data enable us to investigate how the introduction of market mechanisms in the early nineties affected total factor productivity. After deriving the TFP values using growth accounting methodology, we investigate how the contribution of TFP to GDP growth changed with the beginning of transition. In addition, we conduct structural break analysis, taking into an account, not only transition process but the pretransition period as well. Results suggest that transition had a positive impact on total factor productivity growth rates, but not on the share of TFP in the GDP growth rate.

Key words

total factor productivity, transition, growth accounting, structural breaks

JEL classification

O47, P24, N14

1. INTRODUCTION

In this paper we investigate the impact transition had on the total factor productivity in Croatia during 1952 to 2008. We use two methodologies: growth accounting (Barro 1998) in order to estimate total factor productivity (TFP) data series and formal structural break tests (Andrew and Ploberger 1994; Bai and Perron 2003) in order to endogenously estimate location of potential breaks in TFP shares and TFP growth rates.
The aim of transition from command/socialist planned (self-managed) economy in direction of market economy was more efficient use of resources. The process of privatization was aimed at the establishment of private ownership, stabilization followed by legal and institutional reforms was supposed to protect private ownership and create growth friendly environment while liberalization enabled markets to establish market prices in competition with world market economies.

The basic premise of transition process was the hypothesis that private ownership will lead to the more efficient usage of human and physical capital and labor. In terms of growth accounting such theoretical expectation were supposed to be reflected in a change of TFP. More efficient usage of factors of productions basically means higher output with the same amount of capital and labor, or the same level of output with lower level of employment and capacity utilization. In other words transition was a design with a goal of increasing the growth rate and the role of TFP in general.

Therefore, the goal of this paper is to analyze the effect of transition on the growth rate of TFP and the share of TFP in GDP. In order to test for the underlying hypothesis we will use standard growth accounting methodology and a structural break test that endogenously estimates position of a break (Andrew and Ploberger 1994) and a structural break test that endogenously estimates number of breaks and position of break(s) (Bai and Perron 2003).

The data used in this paper are quite unique due to the fact that fixed investment data are available for Croatia starting with 1952. Therefore, regardless of a methodology used for estimate of initial level of capital, perpetual inventory method (PIM) (using 5% depreciation rate) results in similar estimates of physical capital after 1968. Therefore, it is possible to construct data series for TFP from 1968 to 2010 that are robust to changes in initial capital level estimates.

Together with estimate of physical capital using PIM method we estimate two different estimates of human capital using: (i) *Educational attainment approach* (Mankiw, Romer and Weil 1992) and (ii) adapted *Income based approach* (Jorgenson and Fraumeni 1989). The data for educational attainment and average income per educational attainment group are available starting with 1966.

The remainder of the paper is as follows, in Section 1 we summarize the theoretical expectations of transition process; Section 2 discusses the data sources; in Section 3 we outline the growth accounting methodology and the structural break tests; Section 4 summarizes the results; finally Section 5 provides some summary remarks.

2. TRANSITION

There has been almost 22 years since the fall of Berlin Wall and beginning of the transition process of centrally planned economies into market economies. The main ingredients of transition process were: (i) liberalization; (ii) macroeconomic stabilization and control; (iii) restructuring and privatization; and (iv) legal and institutional reforms (Fisher and Gelb 1991).

Liberalization allowed prices to be determined in free markets and lowering trade barriers that had shut off contact with the price structure of the world's market economies. *Macroeconomic stabilization* primarily aimed at putting inflation under control after the initial burst of high inflation that follows from liberalization and the release of freed demand. This process required discipline over the government budget and the growth of money and credit and progress toward sustainable balance of payments. *Restructuring* focused on creating a viable financial sector and reforming the enterprises to make them capable of producing goods that could be sold in free markets. *Privatization* aimed at transferring ownership of enterprises into private hands. *Legal and institutional reforms* redefined the role of the state in these economies by establishing the rule of law, and by the introduction of appropriate competition policies (Fisher and Gelb 1991).

Reforms started with the output fall as a result of both macroeconomic stabilization and the reallocation of resources from unproductive sectors to sectors that would be profitable at world prices. As stabilization took hold, and the new private sectors began to grow while the old sectors declined, aggregate output started to grow. After the initial slump, output was expected to grow more rapidly than in the advanced economies, and some closing of income gaps or even eventual convergence was expected (Fisher and Sahay 2000).

Basic intention of transition was to increase efficiency of labor and capital used in production. "Invisible hand" of private sector was supposed to use resources more efficiently and to produce more output for a given amount of physical capital, labor and/or human capital. In terms of growth accounting, higher efficiency of production was supposed to be reflected in a higher TFP growth rate and larger TFP share in the growth rate of GDP.

In the case of Croatia, transition slump combined with homeland war resulted in 40% drop in GDP between 1990 and 1993 and 25% drop in employment between 1990 and 2000. Jobless growth started after stabilization in 1993 and continued throughout the entire nineties. Employment growth caught up only in 2000, two years after the end of war. In 2008, at the beginning of global crises, GDP was 20% higher and employment 10% lower compared to 1990 (Figure 1).

Although it is obvious that average labor productivity in Croatia increased more than 30% during transition, in order to estimate effects of transition on TFP, data for human and physical capital accumulation are necessary.

Furthermore, besides estimating data series it is important to check robustness of estimates with regard to assumptions made during the process of data compilation. Therefore, we used three estimates of initial level of physical capital, two estimates of human capital and two physical capital depreciation techniques.[1]

3. DATA

We use official and estimated data for GDP, employment, fixed investments, factor shares, education and wages during 1952-2010 period. For the transition period, most of the data are official series, but there are several methodological changes in coverage of GDP and employment.

GDP data during 1995-2010 are from Croatian Bureau of Statistics (CBS 2010, 2011a). It is a real chained GDP series in constant 2000 kunas[2]. Real GDP for 1990-1994 is also official data, but it is expressed in 1990 prices (SLJH 1997) and not with chained price index. GDP growth rates for the pretransition period were estimated ("backcasted") using methodology used in Družić and Tica (2002) for estimation of GDP per capita.

Employment series is official data for paid employment in legal entities, crafts, trades and free lances, excluding private farm employment (CBS 1999, 2001, 2011b). Due to change of methodology and inclusion of police and army personnel after 1998, we have excluded both sectors throughout the entire dataset. Data are consistent for pre and post transition period with an exception of free lancers which were officially included in employment at the begging of transition. Prior to 1990 this sector was excluded from the data, but it was much smaller.[3] Figure 1 shows GDP and employment data used in analysis.

[1] Raguž (2011) already checked for the robustness of results with regard to income factor shares changes.
[2] Kuna is a local currency unit in Croatia.
[3] The number of employed in crafts, trades and free lances increased for 4.8% of total employment in 1990, but only a fraction of this increase is due to change in methodology.

Fixed investment data are from the same sources as GDP for the post 1990 period (CBS 2010, 2011a, SLJH 1997). Prior to 1990, data for investment in basic funds ("osnovna sredstva") were used as a proxy for fixed investments (SGJ 1982, 1989). Compared to Raguž, Družić and Tica (2011) where only investments of legal entities were used, data for basic funds include investments in the rest of the economy and data span from 1952 (compared to 1968 in previous study), which makes TFP estimate less sensitive to the choice of initial capital level.

Data for factor income of physical capital (gross operated surplus) are from official GDP statistics (CBS 2009, 2010 and 2011a). Mixed income from crafts, trades and free lances is excluded from ratio as well as taxes on production and imports. For the pre 1990 period adjusted[4] sum of production surplus and depreciation of capital were used as a proxy for gross operated surplus (SGH 1971-1989).

We use employment and wages in 8 levels of educational attainment of labor force during 1968-2010 in order to estimate human capital:

- VSS - 4 year university degree,
- VŠS - 2 or 3 year university (college) degree,
- VKV - occupational high school degree,
- SSS - general high school degree,
- NSS - 3 year high school degree,
- KV - 2 year high school degree or non-degree,
- PKV - 8 year elementary school and
- NKV - 4 years elementary school

All the data were acquired from official statistics (SGH 1971-1989, SLJH 1991-2010, CBS 2011b) which covered both series on annual basis during transition and biannual basis prior to 1990.

4. METHODOLOGY

In order to estimate effect of transition on TFP we use two different methodologies: (i) growth accounting in tradition of Barro (1998) in order to partition growth rate of GDP into components associated with factor accumulation and technology; and (ii) econometric analysis which tests estimated TFP data and TFP share for potential structural breaks at the begging of transition.

4.1. Growth accounting

Growth accounting analysis starts with neoclassical production function

$$Y = f(A, K, L) \qquad (1)$$

where *A* is the level of technology, *K* is the capital stock and *L* is the quantity of labor. As is well known, the growth rate of output can be partitioned into components associated with factor accumulation and technological progress. In order to get the growth rate of output it is first required to differentiate equation 1 to time and divide it with income *Y*:

$$\frac{\dot{Y}}{Y} = \frac{f_A}{Y}\dot{A} + \frac{f_K}{Y}\dot{K} + \frac{f_L}{Y}\dot{L} \qquad (2)$$

Expressed in terms of growth rates of growth factors and technology it yields to:

[4] Data was adjusted for the ratio between gross operated surplus share in GDP and the share of sum of production surplus and depreciation of capital in social product in 1980, 1985 and 1990.

$$\frac{\dot{Y}}{Y} = \frac{f_A A}{Y}\frac{\dot{A}}{A} + \frac{f_K K}{Y}\frac{\dot{K}}{K} + \frac{f_L L}{Y}\frac{\dot{L}}{L} \qquad (3)$$

If we assume Hicks neutral technology in production function $Y = Af_{hicks}(K,L)$ and that factors are paid their marginal products ($f_K = R$ and $f_K = W$, where R is real (gross) interest rate and W is real wage), then the growth rate of technology can follow from the following equation:

$$\frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \frac{RK}{Y}\frac{\dot{K}}{K} - \frac{WL}{Y}\frac{\dot{L}}{L} \qquad (4)$$

where $\frac{RK}{Y}$ and $\frac{WL}{Y}$ are the respective shares of each factor payment in total product, or - according to national accounts - share of gross operated surplus $\frac{RK}{Y}$ and compensation of employees $\frac{WL}{Y}$ in GDP. The condition $\frac{RK}{Y} + \frac{WL}{Y} = 1$ must hold if all income associated to GDP is attributed to one of the factors. Therefore, if we assume $\alpha = \frac{RK}{Y}$, equation 7 yields to:

$$\frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \alpha\frac{\dot{K}}{K} - (1-\alpha)\frac{\dot{L}}{L} \qquad (5)$$

We also analyze the case with multiple qualities of labor in a production function of the following type:

$$Y = f(A,K,L,h) \qquad (6)$$

where *H* represents human capital. Unfortunately due to lack of data on human capital factor share of GDP we were not able to estimate Solow residual in a way suggested by Barro (1998)[5]:

$$\frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \frac{RK}{Y}\frac{\dot{K}}{K} - \frac{WL_1}{Y}\frac{\dot{L}_1}{L_1} - \frac{WL_2}{Y}\frac{\dot{L}_2}{L_2} - \ldots - \frac{WL_8}{Y}\frac{\dot{L}_8}{L_8} \qquad (7)$$

Therefore, Solow residual in the presence of human capital is estimated with an aggregate of labor and human capital $H = Lh$.

$$\frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \alpha\frac{\dot{K}}{K} - (1-\alpha)\frac{\dot{H}}{H} \qquad (8)$$

Having in mind that only GDP data are available in official statistics and/or as published estimates, we have estimated physical capital and human capital using several methodologies in order to test the robustness of our TFP estimates.

[5] L_1 through L_8 represents eight levels of educational attainment in Croatia

4.2. Physical capital estimate

PIM was used in order to estimate physical capital (Harberger 1978). In addition to Harberger's geometric depreciation of capital, we also use linear depreciation of physical capital suggested by Ganev (2005). Geometric and linear PIM method are combined with three different initial levels of physical capital suggested by Ganev (2005), Easterly and Levine (2001) and Kyriacou (1991).

First method for initial level of physical capital is to divide real fixed investment in the first period I_0 (t=0 is year 1952) with depreciation rate δ (Ganev 2005): [6]

$$K_0 = \frac{I_0}{\delta} \qquad (9)$$

Alternative method is to divide product of GDP in the initial period Y_0 and average investment rate during the entire period (1952-2010) $\sum_0^T \frac{(I/Y)}{T}$ with sum of depreciation rate δ and average growth rate of GDP during the entire period $\sum_0^T \frac{\dot{Y}/Y}{T}$ (Easterly and Levine 2001).

$$K_0 = \frac{Y_0 * \sum_0^T \frac{(I/Y)}{T}}{\sum_0^T \frac{\dot{Y}/Y}{T} + \delta} \qquad (10)$$

The third method is to divide real fixed investment in the first period I_0 with the sum of depreciation rate δ and average growth rate of investment $\sum_0^T \frac{\dot{I}/I}{T}$ (Kyriacou 1991).

$$K_0 = \frac{I_0}{\sum_0^T \frac{\dot{I}/I}{T} + \delta} \qquad (11)$$

In the rest of the text three methods for estimation of initial level of capital are marked $K1$, $K2$ and $K3$ respectively. All three initial levels of physical capital were combined with geometric:

$$K_t = (1-\delta)^t K_0 + \sum_{i=0}^{t-1} (1-\delta)^i I_{t-i} \qquad (12)$$

and linear depreciation method:

$$K_t = (1-t\delta) K_0 + \sum_{i=0}^{t-1} (1-i\delta) I_{t-i} \qquad (13)$$

[6] Depreciation rate δ is assumed to be 5% in all estimates of physical capital.

Three different initial capital level estimates in combination with two depreciation methods have resulted with six different estimates of physical capital that are used in order to test the robustness of our methodology.

4.3. Human capital estimate

We use two different measures of human capital *H*: (i) number of employed corrected for wage differentials between workers of different educational levels H_1, and (ii) total years of schooling of labor H_2 (Wößman 2003).

The first measure of human capital is estimated as:

$$H_1 = \sum_{a=1}^{8} \frac{W_a/L_a}{W_8/L_8} L_a \qquad (14)$$

where $a = 1...8$ represents 8 levels of educational attainment of labor force (VSS=1, VŠS=2, VKV=3, SSS=4, NSS=5, KV=6, PKV=7, NKV=8), W_a/L_a is average wage of workers with educational attainment a and W_8/L_8 is average wage of "row" labor with lowest (NKV) educational attainment.[7]

The second measure is a sum of product of workers L_a in each educational attainment level with the number of years required to reach a degree in each educational attainment level:

$$H_2 = \sum_{a=1}^{8} L_a * years \qquad (15)$$

4.4. Factor shares estimate

Primary incomes in Croatian official data are divided into four categories: compensations of employees, gross operating surplus, mixed income and taxes on production and import. In order to calculate factor shares of capital we have used the share of gross operating surplus in the sum of gross operating surplus and compensations of employees. In that way we have assumed proportional tax on capital and labor, and proportional division of income from crafts, trades and free lances between labor and capital (Barro 1998).

4.5. Structural breaks

We use Andrew and Ploberger (1994) and Bai and Perron (1998; 2003) structural break tests in order to investigate for possibility of one and/or more endogenously determined structural breaks in TFP shares in GDP and TFP growth rates.

Andrew and Ploberger (1994) developed asymptotically optimal test for the problem when nuisance parameter exist under alternative hypothesis but not under null. In the structural change case, the parameter that appears under alternative, but not under null is time π of structural change as a fraction of the total sample. They consider a model:

[7] Jorgenson and Fraumeni (1989) used average hourly labor compensation for individuals classified by the two sexes, 61 age groups and 18 educational attainment groups. Unfortunately, due to data availability problems we had to focus on 8 educational attainment groups only.

$$y_t = \delta_{t'} x_t + u_t \quad (16)$$

where y_t is observed dependent variable at time t, x_t (2×1) is a vector of independent observed variable and $\delta_{t'}$ (2×1) is vector of coefficients where parameters are δ_1 and δ_2 before structural break and $\delta_1+\beta$ and δ_2 after the structural break.
Andrew and Ploberger (1994) developed exponential LM, Wald and LR test that are asymptotically optimal in the one time structural change case in order to test hypothesis $\beta=0$ against alternative $\beta\neq0$.

The asymptotically optimal test statistics for exponential $Exp-LM_T$ is defined as:

$$Exp-LM_T = (1+c)^{-p/2}\int e^{12c(1+c)LM_T(\pi)} dJ(\pi) \quad (17)$$

where $LM_T(\pi)$ is standard LM test, c is scalar depending on a weight function over values of β, $J(\pi)$ is the weight function over values of π. One rejects H_0 if $Exp-LM_T$ exceeds critical value $k_{T\alpha}$ that is determined using the asymptotic null distribution of $Exp-LM_T$.

Biggest limitation of the Andrew and Ploberger (1994) test is the fact that it allows only for one structural breaks under alternative. Therefore, we proceed with Bai and Perron (2003) test that allows more than one structural break in the model.

Bai and Perron (1998; 2003) developed a test that allows for multiple breaks. A sup Wald type test was designed with null hypothesis of no change versus alternative containing arbitrary number of breaks and a procedure that allows one to test null hypothesis of ℓ changes versus alternative of $\ell+1$ changes. They consider a model:

$$y_t = \beta x_{t'} + \delta_j z_{t'} + u_t \quad (18)$$

where $j=1...m+1$ represents number of regimes, m is number of breaks, y_t is dependent variable at time t, x_t ($p\times1$) and z_t ($q\times1$) are vector covariates and β and δ_j ($j=1...m+1$) are corresponding vectors of coefficients. T is the number of observations, the indices $T_1,...,T_m$ are break points and they are treated as unknowns. When $p=0$ we obtain a pure structural change model where all coefficients are subject to change:

$$y_t = \delta_j z_{t'} + u_t \quad (19)$$

Bai and Perron (2003) method is based on least-square principle. For each m-partition ($T_1,...,T_m$), the associated least-square estimates of δ_j are obtained minimizing:

$$RSS_{min} = \sum_{j=1}^{m+1}\sum_{t=T_{j-1}+1}^{T_j}[y_t - z_{t'}\delta_j]^2 \quad (20)$$

We use two tests: $supF_T(k;q)$ that tests no break versus a fixed number (k) of breaks and $supF_T(\ell \mid \ell+1)$ test that sequentially tests ℓ breaks versus $\ell+1$ breaks. $supF_T(k;q)$ is SupF type of test defined as:

$$F_T(\lambda_1,...,\lambda_k;q) = 1T\left(\frac{T-(k+1)q}{qk}\right)\hat{\delta}' R'(R\hat{V}(\hat{\delta})R')^{-1} R\hat{\delta} \quad (21)$$

where k is number of breaks under alternative hypothesis, $\hat{V}(\hat{\delta})$ is the estimate of variance covariance matrix and R is conventional matrix such that $(R\delta)' = (\delta_{1'} - \delta_{2'},...,\delta_{k'} - \delta_{k+1}')$. $SupF_T(\lambda_1,..., \lambda_k;q)$ test minimize global sum of square residuals by choosing structural change as a fraction of the total sample $(\hat{\lambda}_1,...,\hat{\lambda}_k$). This is asymptotically equivalent to maximizing the F-test. The asymptotic distribution depends on a trimming parameter via the imposition of the minimal length h of segment namely $\varepsilon = h/T$.

A test of ℓ versus $\ell+1$ breaks labeled $supF_T(\ell \mid \ell+1)$ is applied to each segment containing the observations $\hat{T}_{t-i}$ to $\hat{T}_t$, where $i = \ell,...,\ell+1$. Null hypothesis is ℓ breaks and alternative, $\ell+1$ breaks. Null hypothesis is rejected if the overall minimal value of sum of squared residuals is sufficiently smaller than the sum of squared residuals from ℓ model. The estimate does not need to be global minimizer of the sum of squared residuals, one can also use sequential one.

5. RESULTS

5.1. Growth accounting

The growth accounting methodology has resulted with 18 different estimates of TFP share in the growth rate of GDP. Figures 8, 9 and 10 shows average growth rates for the four periods of interest.

Figure 8 shows the entire 1952-2010 sample due to the fact that data for physical capital and employment are available during the entire period. Nevertheless, sample for the 1968-2010 period is more representative on two accounts. First, it is comparable to the estimates made with human capital augmented labor that starts with 1968. Second, regardless of the methodology used for the estimation of initial level of capital, by late sixties estimates of physical capital collapse into two estimates. One for the geometric and another for the linear depreciation methodology (Figure 6).

Therefore, three subsamples are used in order to estimate impact of the transition on the TFP share in GDP and to compare results between estimates with and without human capital. Subsample 1968-2010 represents pretransition time, subsample 1995-2010 represents post-war transition average, and 1990-2010 represents transition average including homeland war period (1990-1995).

Figures 8, 9 and 10 quite clearly show that average share of TFP is much higher after 1990 compared to pre 1990 and total sample. When it comes to robustness of the result, all the averages calculated using linear perpetual inventory method indicate strong increase in TFP share after transition period. Linear PIM with raw labor and H2 human capital estimate indicate that TFP share doubled or even tripled, while estimate with H1 human capital implies modest increase in TFP share.

Geometric perpetual inventory method resulted with increase of TFP's share after transition, although the relative size of increase is smaller compared to linear PIM method, and estimate with H1 method results with almost insignificant increase in TFP share. In total, regardless of the PIM depreciation method and estimate of initial capital, average share of TFP strongly increased in 15 out of 18 estimates. In the case of three estimates with geometric PIM and H1 human capital, the increase is insignificant.[8]

Figure 11 shows 18 estimates of TFP series (base index 1967=1). It is obvious that regardless of the initial capital level or depreciation methodology used, all estimates converged to roughly four, or even three different levels of TFP at the end of sample.

The group with the highest level of TFP at the end of sample has three estimates with linear PIM and raw labor. This result is straightforward. Linear depreciation results in a smaller growth rate of physical capital compared to geometric depreciation (Figure 6) and raw labor implies that all improvements in quality of labor (human capital) will end up in Solow residual (Jorgenson and Griliches 1967).

On the other hand, smallest TFP is estimated using geometric PIM and human capital adjusted labor. All six estimates with human capital and geometric PIM converged at the end of sample regardless of the methodology used to estimate human capital (H1 or H2).

Group in between consists of nine estimates of TFP that have converged at the end of sample, although it is possible to divide this group of estimates into six estimates using linear PIM and human capital and three estimates with raw labor and geometric PIM.

Obviously geometric PIM decreases TFP growth rates (higher growth rates of physical capital) as much as quality adjustment of labor (higher growth rate of human capital compared to raw labor) resulting in convergence of all TFP estimates that use either geometric PIM or quality adjusted labor. Estimates with linear PIM and raw labor have highest TFP growth rates, and estimates with both geometric PIM and quality adjusted labor have the smallest growth rates of TFP.

5.2. Structural break tests

In Andrew and Ploberger (1994) structural break test, only in 6 out of 18 TFP growth rate series resulted with significant structural break. In general, TFP estimates based on geometric PIM method resulted with much higher significance levels compared to linear PIM method estimates (Table 1).

Although, the majority of estimates was insignificant, it is interesting to highlight the fact that all estimates indicated year 1993 as a break point (Table 1).[9]

Bai and Perron (2003) test was performed in two steps. First, we have used $supF_T(k;q)$ and $supF_T(\ell \mid \ell+1)$ test in order to endogenously estimate the number of breaks in a data series. Andrew and Ploberger (1994) test assumes only one break, while Bai and Perron (2003) tests endogenously determine number of breaks in data.

Table 2 shows RSS, BIC, LWZ, $supF_T(k;q)$ and $supF_T(\ell \mid \ell+1)$ statistics for 0, 1, 2 and 3 structural breaks in each estimated TFP growth rate series. Following Bai and Perron (2003) application technique, we have decided to focus on $supF_T(\ell \mid \ell+1)$ test in order to find number of breaks that minimize equation 20. We have used trimming $\varepsilon = 0.2$ and critical values by Bai and Perron (2003b).

Results suggest that null hypothesis of ℓ number of breaks cannot be rejected at $\ell = 2$ for a majority of TFP growth rate estimates. Only three estimates (linear PIM and H1 human capital) did not indicate breaks

[8] Figures 9, 9 and 9 are outliers in terms of TFP increase and in terms of negative contribution of human capital to GDP.
[9] Andrew and Ploberger (1994) structural break test did not find significant structural breaks in the series for TFP growth rate share in GDP growth rate. The data is available from authors upon request.

in $supF_T(\ell \mid \ell+1)$ test, but on the other hand $supF_T(k;q)$ test implied two breaks at 5% significance level. Also, two estimates based on H2 human capital and linear PIM imply existence of only one break in $supF_T(\ell \mid \ell+1)$ test with quite ambiguous results for $supF_T(k;q)$ (Table 2).[10]

We have proceeded with the estimation of two break points using Bai and Perron (2003) test for all estimated TFP growth rate series. Table 3 shows the results of the test. For all 18 TFP growth rate series, Bai and Perron (2003) test estimated first break in 1979 and second break in 1993.

Compared to Andrew and Ploberger (1994), Bai and Perron (2003) test estimated additional break for most of the series and provided additional evidence that break in TFP growth rate occurred in 1993. Figure 1 shows the GDP level during the period and it is obvious that first estimated break corresponds to the beginning of the period of GDP stagnation during eighties and second break in 1993 represents turning point for GDP growth during the transition process.

When it comes to 95% significance band for estimated breaks it should be noted that bands are quite wide, covering sometimes more than a decade as a consequence of a short data sample. On the other hand, exactly the same break years are indicated in all 18 estimates, which might be interpreted as a sign of robustness.
When it comes to estimated average growth rates of TFP during three regimes, results are even more interesting. Prior to 1979, average growth rate of TFP in Croatia was positive between 0.7 and 1.6% depending on a TFP estimate. During the political turmoil in former-Yugoslavia between 1979 and 1993, average TFP growth rate was negative between -2.3 and -3.6%. After transition started, TFP growth rate became positive again ranging from 2.2 to 2.8% depending on the TFP estimate.

6. CONCLUSION

Structural break tests have found quite strong evidence of two structural breaks in TFP growth rates and zero significant structural breaks in the share of TFP growth rate in GDP growth rate. Results for both series are quite robust and have provided quite strong evidence that transition had profound effect on TFP growth rates, but insignificant effect on share of TFP in GDP.

In other words we can conclude that transition reforms have changed trend in TFP growth rates from negative to positive and that post transition growth rates are quite higher compared to growth rates prior to first structural break in 1979.

On the other hand, higher post-transitional TFP growth rates did not affect the share of TFP growth in GDP growth. That can be interpreted as a consequence of similar effect of transition on other growth factors. If the impact of transition break in 1993 was similar on TFP, physical and human capital and labor, relative importance of growth factors should not change in a significant way.

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TABLES

Table 1: Andrews-Ploberger test - TFP growth rates

Series	Break Location	AP statistics	P-value
K1geoL	1993	1.702	0.076 *
K2geoL	1993	1.893	0.060 *
K3geoL	1993	1.994	0.053 *
K1linL	1993	1.001	0.196
K2linL	1993	1.095	0.171
K3linL	1993	1.146	0.159
K1geoH1	1993	1.202	0.147
K2geoH1	1993	1.341	0.122
K3geoH1	1993	1.418	0.110
K1linH1	1993	0.698	0.314
K2linH1	1993	0.748	0.290
K3linH1	1993	0.778	0.276
K1geoH2	1993	1.648	0.082 *
K2geoH2	1993	1.834	0.065 *
K3geoH2	1993	1.932	0.057 *
K1linH2	1993	0.957	0.209
K2linH2	1993	1.053	0.182
K3linH2	1993	1.104	0.169

Note: ***, **, and * represent significance at the 1%, 5%, and 10% level respectively.

Table 2: Estimated number of breaks with Bai Perron break - TFP growth rates

Series	No. of breaks	RSS	BIC	LWZ	$F_T(k;q)$	$F_T(\ell \mid \ell+1)$
K1geoL	0	0.071	-6.35	-6.30		
	1	0.056	-6.49	-6.39	10.78**	10.78**
	2	0.042	-6.62*	-6.42*	14.00***	14.10***
	3	0.043	-6.41	-6.11	7.98***	-1.56
K2geoL	0	0.070	-6.35	-6.30		
	1	0.055	-6.51	-6.41	11.60**	11.60**
	2	0.041	-6.62*	-6.43*	13.97***	13.23**
	3	0.043	-6.41	-6.11	7.98***	-1.53
K3geoL	0	0.070	-6.36	-6.31		
	1	0.055	-6.52	-6.42	12.02***	12.02***
	2	0.041	-6.63*	-6.43*	13.96***	12.80**
	3	0.043	-6.41	-6.12	7.98***	-1.51
K1linL	0	0.072	-6.34	-6.29		
	1	0.061	-6.41	-6.32*	7.53*	7.53*
	2	0.049	-6.45*	-6.26	9.05**	9.27***
	3	0.046	-6.34	-6.05	6.97***	2.54
K2linL	0	0.071	-6.35	-6.30		
	1	0.059	-6.44	-6.34*	8.07*	8.07*
	2	0.049	-6.46*	-6.26	8.99**	8.63***
	3	0.046	-6.35	-6.06	6.93***	2.56
K3linL	0	0.070	-6.35	-6.30		
	1	0.059	-6.45	-6.35*	8.34**	8.34**
	2	0.049	-6.46*	-6.27	8.95**	8.32***
	3	0.046	-6.36	-6.06	6.91***	2.57
K1geoH1	0	0.068	-6.39	-6.34		
	1	0.056	-6.49	-6.39*	8.52**	8.52**
	2	0.044	-6.56*	-6.37	10.81***	11.22**
	3	0.044	-6.39	-6.09	6.86	0.03
K2geoH1	0	0.067	-6.39	-6.35		

	1	0.055	-6.51	-6.41*	9.20**	9.20**
	2	0.044	-6.57*	-6.37	10.74***	10.44**
	3	0.044	-6.39	-6.10	6.82***	0.03
K3geoH1	0	0.067	-6.40	-6.35		
	1	0.055	-6.51	-6.42*	9.54**	9.54**
	2	0.044	-6.57*	-6.37	10.71***	10.05**
	3	0.044	-6.40	-6.10	6.80***	0.03
K1linH1	0	0.068	-6.39	-6.34*		
	1	0.060	-6.43*	-6.33	5.83	5.83
	2	0.050	-6.43	-6.23	7.02**	7.45
	3	0.050	-6.26	-5.96	4.53*	0.18
K2linH1	0	0.068	-6.39	-6.35		
	1	0.059	-6.45*	-6.35*	6.26	6.26
	2	0.050	-6.43	-6.24	6.91**	6.85
	3	0.050	-6.27	-5.97	4.46*	0.18
K3linH1	0	0.067	-6.40	-6.35		
	1	0.058	-6.45*	-6.36*	6.47	6.47
	2	0.050	-6.43	-6.24	6.86**	6.56
	3	0.050	-6.27	-5.97	4.43*	0.18
K1geoH2	0	0.071	-6.34	-6.30		
	1	0.057	-6.48	-6.39	10.59**	10.59**
	2	0.043	-6.59*	-6.39*	13.00***	12.71**
	3	0.045	-6.37	-6.08	7.42***	-1.48
K2geoH2	0	0.071	-6.35	-6.30		
	1	0.056	-6.50	-6.40*	11.38**	11.38**
	2	0.043	-6.59*	-6.39	12.96***	11.87**
	3	0.045	-6.38	-6.08	7.43***	-1.42
K3geoH2	0	0.071	-6.35	-6.30		
	1	0.055	-6.51	-6.41*	11.78**	11.78**
	2	0.043	-6.59*	-6.40	12.95***	11.46**
	3	0.044	-6.38	-6.08	7.44***	-1.39
K1linH2	0	0.071	-6.34	-6.29		
	1	0.061	-6.42	-6.32*	7.45*	7.45*
	2	0.050	-6.44*	-6.24	8.51**	8.42***
	3	0.047	-6.32	-6.02	6.37**	2.06
K2linH2	0	0.071	-6.35	-6.30		
	1	0.059	-6.44	-6.34*	7.97*	7.97*
	2	0.050	-6.44*	-6.25	8.43**	7.79
	3	0.047	-6.32	-6.02	6.32**	2.07
K3linH2	0	0.070	-6.35	-6.30		
	1	0.059	-6.44*	-6.35*	8.22**	8.22**
	2	0.050	-6.44	-6.25	8.39**	7.49
	3	0.047	-6.32	-6.03	6.30**	2.08

Note: For BIC and LWZ * represents minimum. For supF tests ***, **, and * represent significance at the 1%, 5%, and 10% level respectively. SupF critical values are for $q=1$, $\varepsilon=0.2$ (Bai and Perron 2003b).

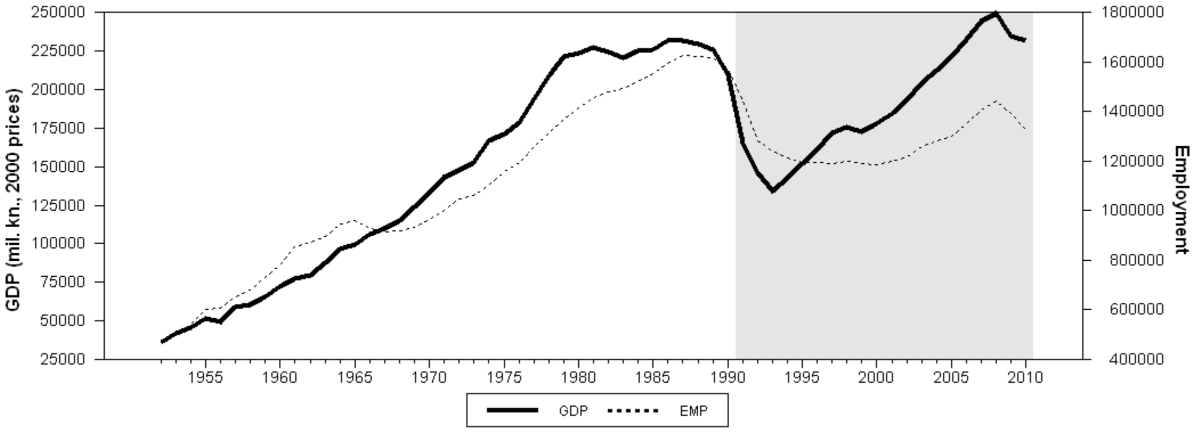
Table 3: Estimated break locations with Bai Perron break test - TFP growth rates

Series	Break(s) Location	95%		Constant		
		Lower	Upper	$\leq$break1	$\leq$break2	$>$ break2
K1geoL	1979	1966	1980	0.015	-0.032	0.028
	1993	1986	2000			
K2geoL	1979	1966	1980	0.013	-0.032	0.028
	1993	1986	2000			
K3geoL	1979	1965	1980	0.012	-0.032	0.028
	1993	1986	2000			
K1linL	1979	1965	1982	0.018	-0.024	0.028

	1993	1977	2000			
K2linL	1979	1964	1981	0.016	-0.024	0.028
	1993	1977	2000			
K3linL	1979	1964	1981	0.015	-0.024	0.028
	1993	1977	2000			
K1geoH1	1979	1967	1980	0.012	-0.031	0.023
	1993	1985	2000			
K2geoH1	1979	1966	1980	0.010	-0.032	0.022
	1993	1985	2000			
K3geoH1	1979	1965	1980	0.009	-0.032	0.022
	1993	1985	2000			
K1linH1	1979	1966	1981	0.014	-0.023	0.023
	1993	1975	2000			
K2linH1	1979	1965	1980	0.013	-0.023	0.023
	1993	1975	2000			
K3linH1	1979	1964	1980	0.012	-0.023	0.023
	1993	1975	2000			
K1geoH2	1979	1965	1980	0.010	-0.035	0.023
	1993	1986	2001			
K2geoH2	1979	1964	1980	0.008	-0.036	0.023
	1993	1986	2001			
K3geoH2	1979	1963	1980	0.007	-0.036	0.023
	1993	1986	2001			
K1linH2	1979	1963	1982	0.012	-0.027	0.024
	1993	1977	2001			
K2linH2	1979	1962	1981	0.011	-0.027	0.024
	1993	1977	2001			
K3linH2	1979	1961	1981	0.010	-0.027	0.024
	1993	1977	2001			

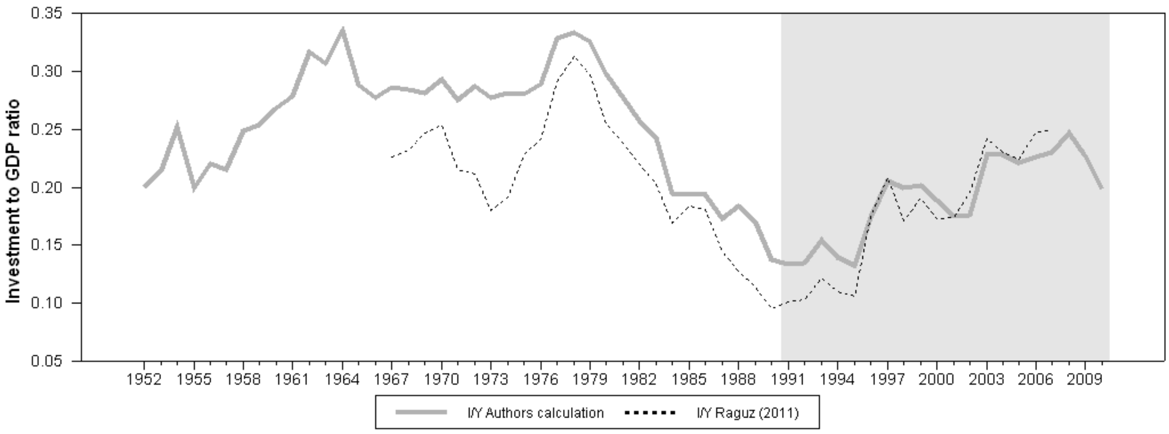
FIGURES

Figure 1: GDP and employment



Source: CBS 1999, 2001, 2010, 2011a, 2011b, SLJH 1997

Figure 2: Investment to GDP ratio update

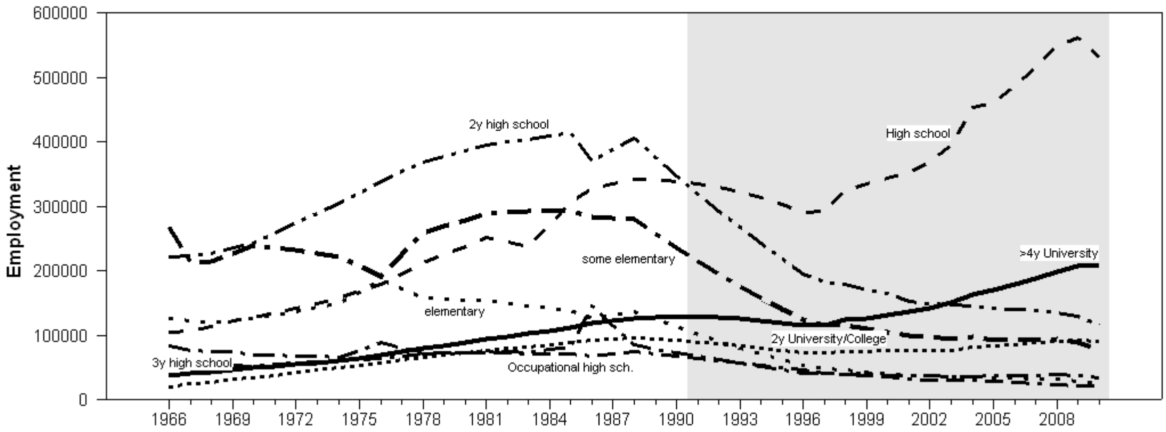


Source: CBS 2010, 2011a, SLJH 1997, SGJ 1982, 1989

Figure 3: Factor share of capital

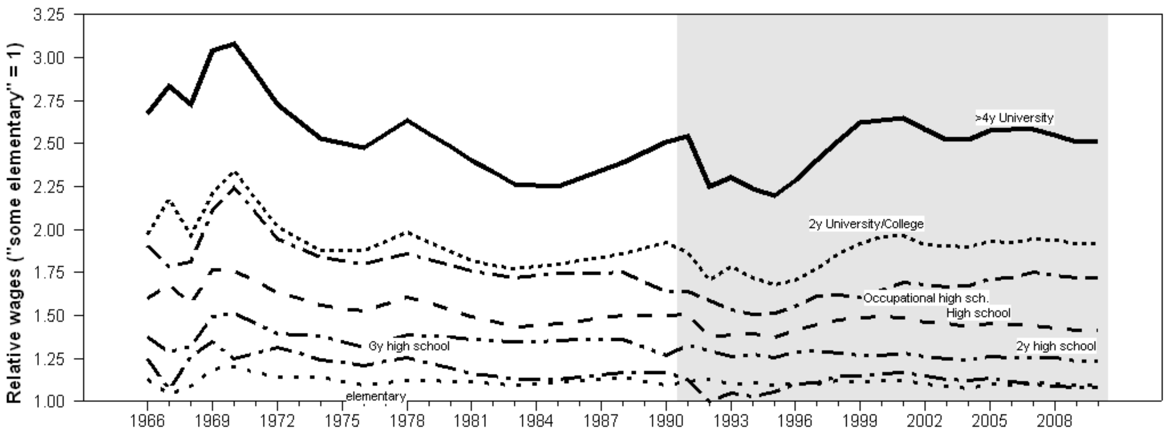
Source: SGH 1971-1989, SLJH 1991-2010, CBS 2009, 2010 and 2011a

Figure 4: Employment per educational attainment



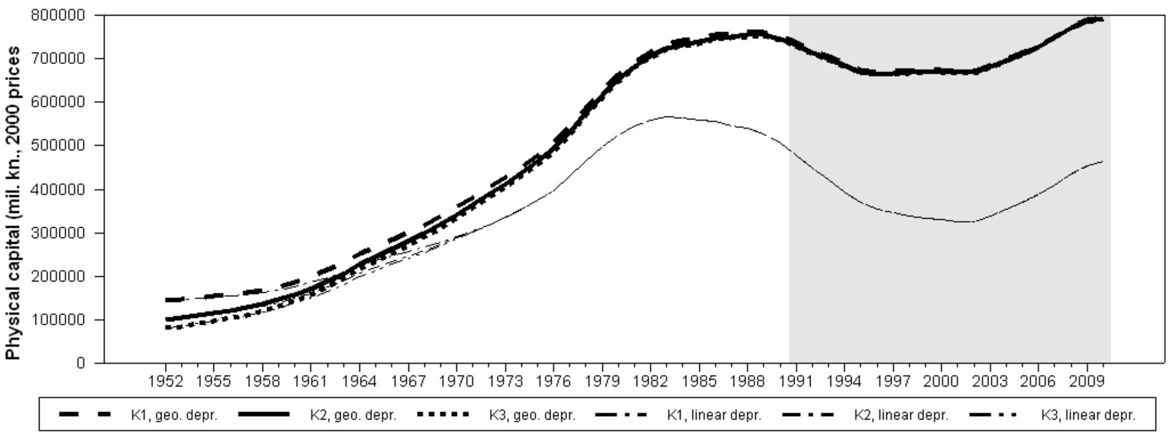
Source: SGH 1971-1989, SLJH 1991-2010, CBS 2011b

Figure 5: Relative wages NKV=1



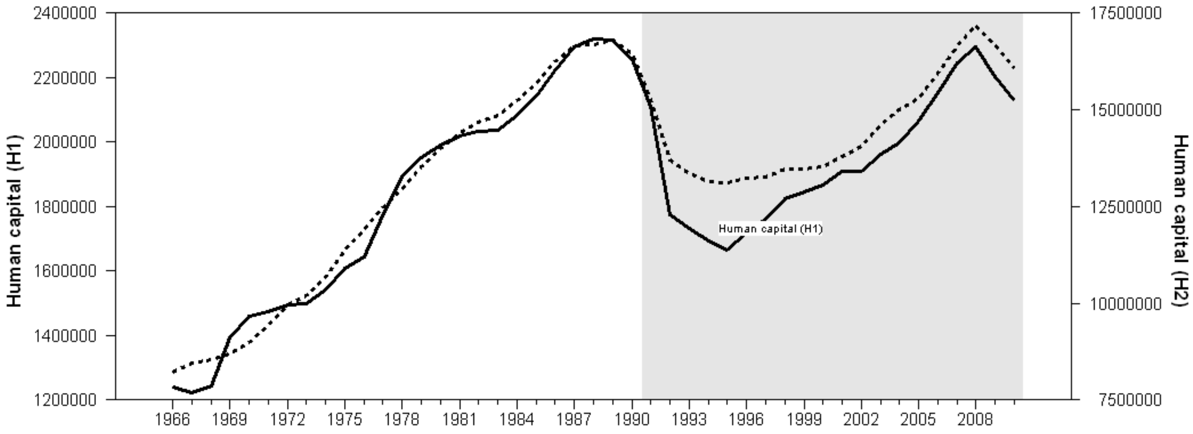
Source: SGH 1971-1989, SLJH 1991-2010, CBS 2011b

Figure 6: Physical capital



Source: Authors calculation

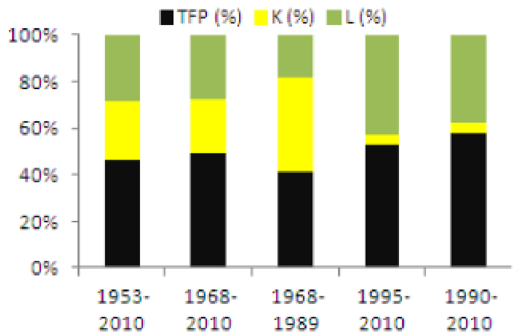
Figure 7: Human capital



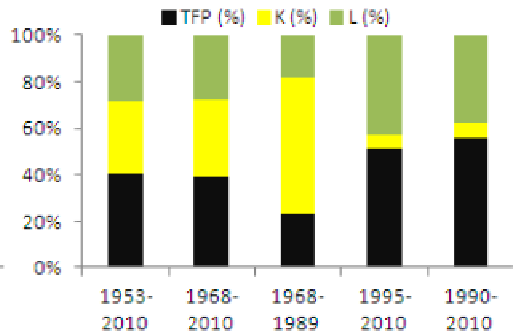
Source: Authors calculation

Figure 8: Growth accounting with raw labor

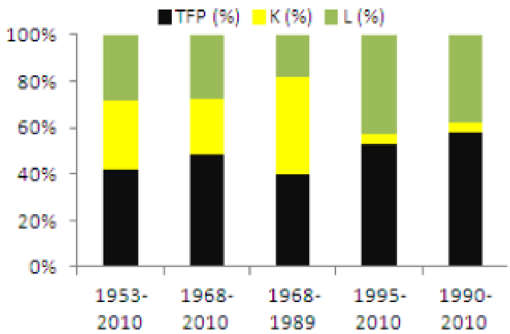
(a) $K_0 = \frac{I_0}{\delta}$, geometric depreciation



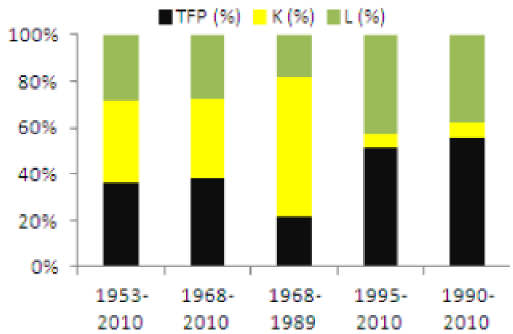
(b) $K_0 = \frac{I_0}{\delta}$, linear depreciation



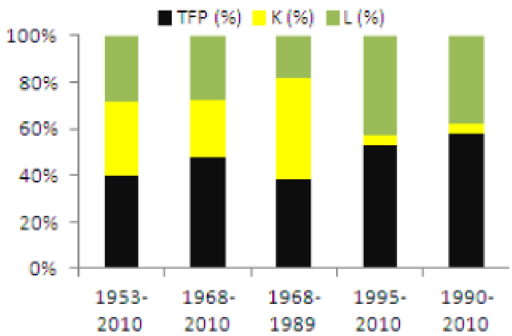
(c) $K_0 = \frac{Y_0 * avg(I/Y)}{avg(g_Y)+\delta}$, geometric depreciation



(d) $K_0 = \frac{Y_0 * avg(I/Y)}{avg(g_Y)+\delta}$, linear depreciation



(e) $K_0 = \frac{I_o}{avg(g_I)+\delta}$, geometric depreciation



(f) $K_0 = \frac{I_o}{avg(g_I)+\delta}$, linear depreciation

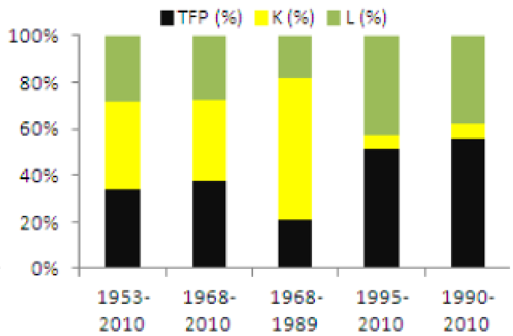
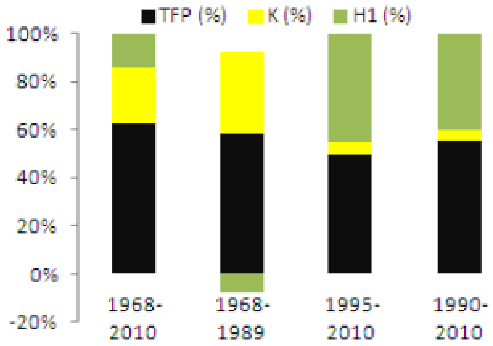
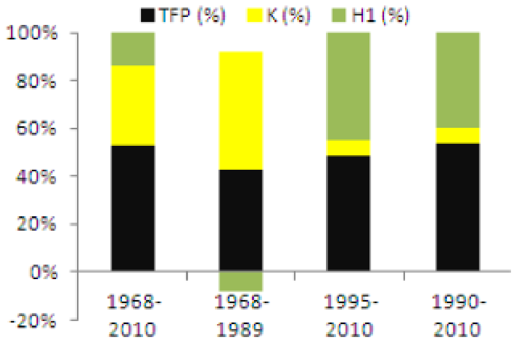


Figure 9: Growth accounting with human capital (relative wages) adjusted labor

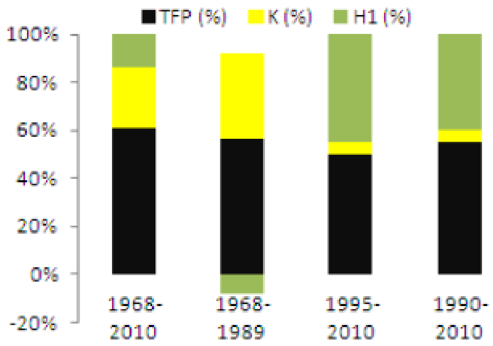
(a) $K_0 = \frac{I_0}{\delta}$, geometric depreciation



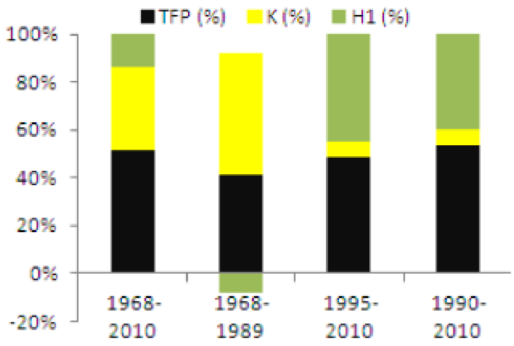
(b) $K_0 = \frac{I_0}{\delta}$, linear depreciation



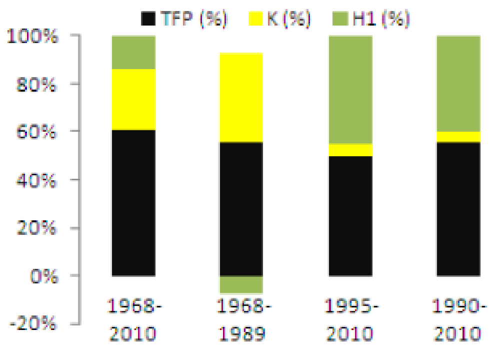
(c) $K_0 = \frac{Y_0 * avg(I/Y)}{avg(g_Y)+\delta}$, geometric depreciation



(d) $K_0 = \frac{Y_0 * avg(I/Y)}{avg(g_Y)+\delta}$, linear depreciation



(e) $K_0 = \frac{I_o}{avg(g_I)+\delta}$, geometric depreciation



(f) $K_0 = \frac{I_o}{avg(g_I)+\delta}$, linear depreciation

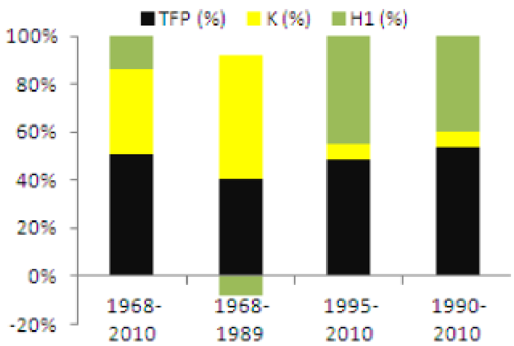


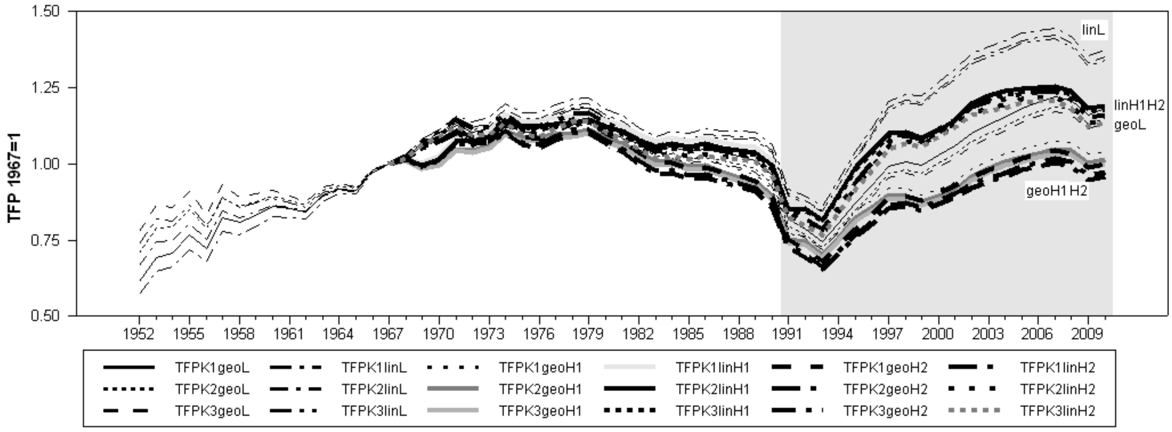
Figure 10: Growth accounting with human capital (average years of schooling) adjusted labor

(a) $K_0 = \frac{I_0}{\delta}$, geometric depreciation (b) $K_0 = \frac{I_0}{\delta}$, linear depreciation

(c) $K_0 = \frac{Y_0 * avg(I/Y)}{avg(g_Y)+\delta}$, geometric depreciation (d) $K_0 = \frac{Y_0 * avg(I/Y)}{avg(g_Y)+\delta}$, linear depreciation

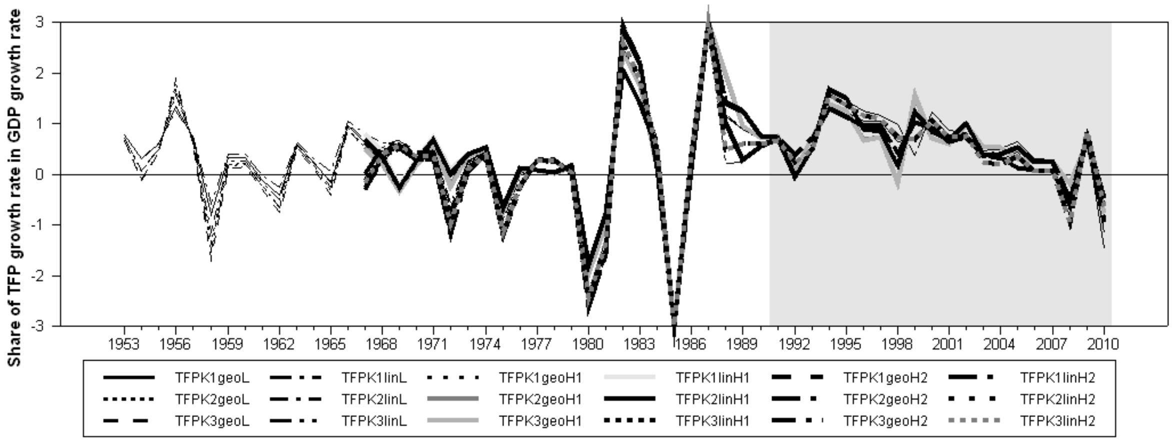
(e) $K_0 = \frac{I_o}{avg(g_I)+\delta}$, geometric depreciation (f) $K_0 = \frac{I_o}{avg(g_I)+\delta}$, linear depreciation

Figure 11: TFP 1967=1



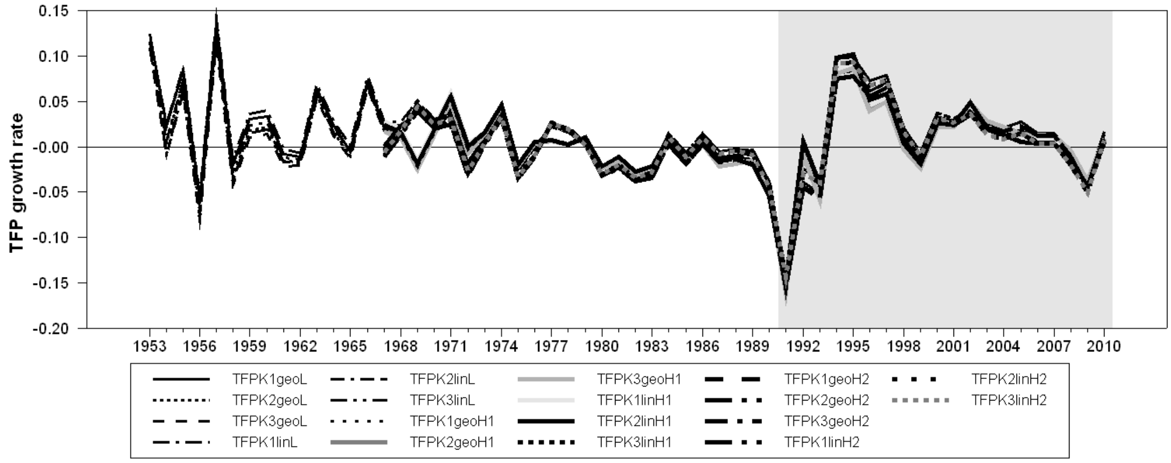
Source: Authors calculation

Figure 12: Shares of TFP growth rates in GDP growth rates



Source: Authors calculation

Figure 13: TFP growth rates



Source: Authors calculation

DATA APPENDIX

Table 4: Estimated Phyisical Capital and GDP (millions of kuna, 2000 prices)

Year	Estimate of Physical Capital (Kgeo1)	Estimate of Physical Capital (Kgeo2)	Estimate of Physical Capital (Kgeo3)	Estimate of Physical Capital (Klin1)	Estimate of Physical Capital (Klin2)	Estimate of Physical Capital (Klin3)	GDP and GDP Estimate
1952	144.891	**100.461**	80.021	144.891	100.461	80.021	36.200
1953	146.639	**104.432**	85.013	146.639	104.432	85.013	42.036
1954	150.708	**110.610**	92.163	150.346	110.359	91.963	45.261
1955	153.473	**115.380**	97.855	152.382	114.617	97.242	51.643
1956	156.679	**120.491**	103.842	154.482	118.939	102.586	49.440
1957	161.510	**127.131**	111.315	157.824	124.502	109.171	58.683
1958	168.416	**135.756**	120.731	162.849	131.749	117.440	60.136
1959	176.636	**145.609**	131.334	168.784	139.905	126.618	65.541
1960	187.157	**157.681**	144.121	176.599	149.942	137.677	72.014
1961	199.305	**171.304**	158.421	185.601	161.164	149.922	77.328
1962	214.503	**187.901**	175.663	197.183	174.968	164.748	79.440
1963	230.780	**205.509**	193.882	209.347	189.353	180.155	88.002
1964	251.535	**227.527**	216.482	225.452	207.680	199.504	96.314
1965	267.528	**244.720**	234.227	236.217	220.667	213.513	99.221
1966	283.742	**262.075**	252.107	246.577	233.248	227.116	106.533
1967	301.077	**280.493**	271.023	257.387	246.280	241.169	110.190
1968	318.748	**299.194**	290.198	267.825	258.939	254.851	115.163
1969	337.717	**319.140**	310.593	278.806	272.142	269.076	123.884
1970	359.733	**342.085**	333.966	292.040	287.597	285.553	132.491
1971	381.239	**364.474**	356.761	303.918	301.697	300.675	143.233
1972	404.464	**388.536**	381.209	316.616	*	*	147.184
1973	426.686	**411.555**	404.594	334.602			153.037
1974	452.180	**437.805**	431.192	355.299			166.409
1975	477.625	**463.970**	457.687	375.451			171.257
1976	505.387	**492.414**	486.446	397.304			178.583
1977	543.797	**531.473**	525.803	429.154			193.820
1978	586.168	**574.460**	569.074	464.336			208.543
1979	628.896	**617.774**	612.657	499.264			221.022
1980	664.083	**653.517**	648.655	526.018			223.763
1981	693.809	**683.771**	679.152	546.706			227.033
1982	716.870	**707.334**	702.947	560.144			224.058
1983	734.532	**725.472**	721.304	567.707			220.606
1984	741.636	**733.029**	729.070	564.270			225.307
1985	748.271	**740.095**	736.333	560.142			225.625
1986	755.687	**747.920**	744.346	556.370			231.871
1987	757.895	**750.516**	747.122	546.999			231.643
1988	762.219	**755.209**	751.984	539.429			229.486
1989	762.522	**755.863**	752.799	527.581			225.966
1990	753.156	**746.830**	743.919	505.904			209.813

1991	737.583	**731.573**	728.808	478.059			165.606
1992	720.320	**714.610**	711.984	448.615			146.233
1993	705.088	**699.664**	697.169	421.472			134.490
1994	689.710	**684.557**	682.186	394.505			142.344
1995	675.463	**670.567**	668.315	369.247			152.068
1996	669.671	**665.020**	662.881	353.124			160.942
1997	671.572	**667.154**	665.121	345.587			171.859
1998	673.036	**668.839**	666.908	339.122			175.513
1999	674.185	**670.197**	668.363	334.141			172.875
2000	674.031	**670.243**	668.501	329.777			178.118
2001	672.636	**669.037**	667.381	325.818			184.630
2002	672.992	**669.573**	668.000	325.071			193.636
2003	685.857	**682.609**	681.115	338.039			204.037
2004	699.994	**696.908**	695.489	353.272			212.460
2005	714.028	**711.097**	709.749	368.880			221.553
2006	730.981	**728.197**	726.916	387.842			232.487
2007	750.733	**748.088**	746.871	410.059			244.251
2008	774.832	**772.319**	771.163	436.796			249.550
2009	789.344	**786.957**	785.858	454.179			234.599
2010	795.959	**793.691**	792.648	463.649			231.804

Note: Klin2 and Klin3 are equal to Klin1 after 20 periods regardless of the initial value of the physical capital. Prior to year 1990 Družić and Tica (2002) methodology is used to "backcast" estimate of GDP reestimated to 2000 prices.

Table 4: Employment, Investment to GDP ratio, Estimated Factor Share of Physical Capital and Estimated Human Capital

Year	Employment	Investment to GDP ratio	Factor share of Physical Capital (α)	Estimate of Human capital augmented labor force (H1)	Estimate of Human capital augmented labor force (H2)
1952	477.000	0,2001			
1953	500.000	0,2139	0,3208		
1954	544.000	0,2519	0,5702		
1955	602.000	0,1995	0,5685		
1956	606.000	0,2201	0,5667		
1957	651.000	0,2158	0,5459		
1958	681.000	0,2491	0,5244		
1959	729.000	0,2539	0,5131		
1960	781.000	0,2687	0,5071		
1961	853.000	0,2781	0,3877		
1962	872.000	0,3168	0,2957		
1963	894.000	0,3068	0,3710		
1964	945.000	0,3353	0,4189		
1965	959.000	0,2879	0,4147		
1966	926.000	0,2778	0,3854	1.241.026	8.225.172
1967	913.000	0,2861	0,3566	1.223.294	8.455.694
1968	917.000	0,2842	0,3573	1.243.950	8.539.936
1969	930.948	0,2818	0,3605	1.391.699	8.688.586

1970	966.484	0,2936	0,3616	1.457.795	8.997.369
1971	1.003.272	0,2757	0,3670	1.473.922	9.439.932
1972	1.047.297	0,2873	0,3713	1.494.633	9.958.651
1973	1.060.476	0,2774	0,3837	1.499.053	10.182.428
1974	1.101.323	0,2814	0,3977	1.541.131	10.676.881
1975	1.158.033	0,2806	0,4023	1.607.025	11.378.493
1976	1.196.336	0,2892	0,4021	1.645.195	11.911.701
1977	1.258.470	0,3285	0,4036	1.771.458	12.463.568
1978	1.313.452	0,3336	0,4122	1.891.330	12.938.388
1979	1.369.933	0,3259	0,4221	1.949.927	13.521.130
1980	1.414.296	0,2978	0,4300	1.988.875	13.986.208
1981	1.454.922	0,2772	0,4265	2.020.365	14.415.967
1982	1.478.617	0,2578	0,4187	2.033.473	14.678.882
1983	1.494.719	0,2425	0,4264	2.035.352	14.867.176
1984	1.518.892	0,1945	0,4460	2.083.650	15.235.189
1985	1.550.839	0,1938	0,4631	2.143.219	15.685.894
1986	1.595.113	0,1933	0,4456	2.220.089	16.249.629
1987	1.627.053	0,1726	0,4302	2.295.391	16.647.751
1988	1.623.648	0,1840	0,4417	2.321.271	16.685.505
1989	1.618.204	0,1700	0,4422	2.316.719	16.788.726
1990	1.571.666	0,1371	0,3738	2.255.706	16.460.487
1991	1.443.535	0,1334	0,3164	2.111.137	15.260.522
1992	1.282.901	0,1341	0,3791	1.773.788	13.688.544
1993	1.238.854	0,1545	0,4203	1.733.500	13.340.417
1994	1.210.691	0,1396	0,3917	1.692.272	13.156.231
1995	1.195.466	0,1331	0,3632	1.663.856	13.108.371
1996	1.195.118	0,1739	0,3444	1.718.163	13.222.107
1997	1.187.871	0,2059	0,3405	1.761.950	13.246.881
1998	1.199.459	0,1997	0,3290	1.824.716	13.475.769
1999	1.191.267	0,2013	0,2990	1.844.921	13.471.660
2000	1.185.519	0,1884	0,2909	1.866.659	13.516.897
2001	1.200.294	0,1750	0,3149	1.907.708	13.783.096
2002	1.216.602	0,1755	0,3251	1.908.330	14.043.867
2003	1.257.404	0,2280	0,3568	1.961.998	14.612.837
2004	1.282.941	0,2279	0,3707	1.996.962	14.996.901
2005	1.299.298	0,2213	0,3544	2.064.528	15.284.859
2006	1.350.769	0,2265	0,3300	2.152.302	15.952.098
2007	1.403.776	0,2305	0,2998	2.244.098	16.639.975
2008	1.444.519	0,2470	0,2998	2.294.674	17.180.596
2009	1.391.247	0,2270	0,2998	2.201.771	16.668.307
2010	1.327.873	0,1988	0,2998	2.127.122	16.057.798