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The Effects on Public Sector Investments on Economic Growth of Croatia

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The effects of public sector investments on economic growth of Croatia[1]

Abstract

The paper deals with effects of public investments on economic growth of Republic of Croatia. Due to lack of official statistics, necessary datasets were derived by the author for the period 1997-2006. Capital stocks necessary for the estimation are derived by Perpetual Inventory Method (PIM). For the estimation purposes several models of panel regression are used. Reason for that is in obtaining the robustness of the results. Significant, positive and robust results are obtained in case of construction investments effects on growth. High spillover effects are also found which was expected due to small size of Croatian regions. Findings point out that keeping the high public investment level in Croatia together with improvement in institutional surroundings would be beneficial for economic growth.

Key words: public investments, economic growth, Perpetual Inventory Method, panel regression, Croatia

1. Introduction

Reaching the high level of economic development and high growth rates is one of the most important goals of transition economies. Most of the transition economies in Europe have set the goal of becoming a member of the EU. This path was determined for the Republic of Croatia as well. Accessing the EU was considered to be a shortcut toward higher levels of development. In comparison to the old EU members, all these economies have had many deficiencies, especially in quantity and quality of capital stocks necessary for the production of goods and services. The need for more investments is not just a reality for transition economies but the old EU members are also considered to have "infrastructure shortcoming crises". However, little attention has been devoted to the role of public investments and especially to investments that originated at regional and local government levels in pursuing goals of economic development. This is not unusual because this kind of research is still rare even in developed economies. There is no evidence of any comprehensive research on that issue for transition economies.

The understanding of the role of capital in the Croatian economy is quite complex for several reasons. Croatia belongs to a group of "transition economies" that turned to capitalism and at the same time gained sovereignty. In addition, the war that ended in 1995 resulted in substantial direct and indirect damages. The privatization of public enterprises started early in 1990s and it was hard to capture data on public and private ownership of assets under such circumstances. Data on capital accumulation are also unreliable and official capital stock estimates still do not exist. Due to these reasons lack of empirical studies on the effects of capital accumulation in Croatia is not surprising.

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The only exception is the study of Lovrinčević et al. (2004) that dealt with the efficiency of investments based on the incremental capital-output ratio.

The investment activities of the public sector establish foundations for economic growth and development. Their impact comes from both direct and indirect effects – either through increased employment and wages and the rise of productivity of the private sector. Therefore, for the Republic of Croatia as a transition economy with great infrastructure needs and the condition of high unemployment rates, it is important to maintain a high level of public investments. In addition, it is necessary to improve the institutional framework of the public investment process in order to increase efficiency and boost positive effects.

In the second part, after the introduction, chronological overview of empirical research of the capital-growth relationship follows. By third and fourth section an overview of Croatian economy and economic divergences in Croatian regions is presented. In the fifth part the methodology and dataset construction is described. Sixth part provides the estimation results. Conclusion summarizes the result of research and points out some constraints and future research proposals.

2. Chronological overview of empirical research

Even though the relationship of public investments and economic growth has long period of research and voluminous literature contributions can be found, this area is still far from definite answers. There are many reasons for such case. One of the most important reasons is in lack of appropriate datasets. Furthermore, it is hard to capture the complexity of the investment process featured by numerous factors that channel their effects on growth. Different empirical methodologies and approaches used were not able to provide holistic concept so far. In addition, investment activity is highly dependent on particular economy surroundings; therefore it is necessary to devote attention to specific spatial and institutional features of certain area of interest (region, country). However, partial analysis from different aspects can provide some valuable policy recommendations. For such reasons it is important to familiarize with numerous approaches used in literature and each of them presents a little piece of the big puzzle.

The review of empirical literature focuses only on some of the main turning points in the research on the relationship between investments and economic growth. The evolution of empirical contributions to the relevant issue begins with the papers of Abramowitz (1956) and Solow (1957). This very beginning of econometric research was founded in neoclassical theory and a model developed by Solow and Swan. For the first time it was possible to distinguish the contributions of individual factors of production on economic growth. Previously, relations between inputs in the production function were examined by the use of input-output techniques, capital-output ratios and short-run multipliers and placed much emphasis on the demand side of the economy. The new approach offered the possibility of exploring the long-term effects of factors of economic growth and was supply-side oriented.

Following these seminal articles, there was a certain period when not much of the literature on growth and investments was produced. Research in that period had a regional character. Mera (1973) examined effects of public capital on the regional productivity of Japanese regions and found significant positive effects. Biehl (1986), in a report for the EEC, showed the positive impact of infrastructure on regional development. Looney and Frederiksen (1981) studied the link between income, productivity and public capital for the Mexican states. Although these papers noted that public infrastructure has a significant positive impact on economic growth, not much attention was focused on those findings.

Further empirical evidence was based on the same production function framework and until 1990s there was a period when not much research on these issues was conducted. But then, after Ashauer's paper (1989) research in this area increased dramatically. There are several reasons for such developments. First of all, Ashauer's paper was launched at the time when economists were trying to explain the reasons for productivity decline in the US, and the shortcoming of investments was a plausible and possible explanation. Also, datasets on capital stocks and investments, due to improvements of methodology in collecting and processing of data, provided a much better basis for conducting econometrical examinations. Furthermore, there was a tremendous improvement and development in various econometric techniques. Within the time series analysis techniques many new concepts emerged, especially applicable in the area of macroeconomics. Finally, a longer time span of the data helped in providing better estimates using larger samples. Of course, it has to be pointed out that most research was conducted for the U.S. with some exceptions – Netherlands and Spain. European countries still do not have appropriate data sets on capital stocks so therefore it is expected to observe a rise of research in that area in EU from the year 2000.

This approach has been criticized on several grounds. First, the assumption of a Cobb-Douglas production function frequently used in empirical studies restricts the substitution elasticity of the factors of production to unity. It is questionable whether this restriction on the form of the production function gives a satisfactory description of data. Second, the explanatory variables: labor along with private and public capital is assumed to be exogenous implying that the factors of production cause output but not the other way around. Third, nonstationarity of data is an issue. Numerous studies estimated production functions in levels without testing for cointegration. The positive correlation between public capital and output found in these studies may thus be spurious. For example, Sturm and de Haan (1995) reexamined Aschauer's (1989) findings for the United States. Their results show that the variables used in the regression are not cointegrated implying that the production function should be estimated in first differences rather than in levels. Estimating a model in first differences Sturm and de Haan (1995) obtain results that are quite different from those obtained by Aschauer (1989). They concluded that the positive relationship between public capital and output found by Aschauer for the United States is not robust. Another problem also mentioned in numerous studies is the multicollinearity issue which jeopardizes the reliability of estimates.

Together with the traditional production function approach, numerous studies use the cost

or profit function approach. Some authors classify these approaches as behavioral because they are based on the optimization of the behaviors of economic agents either by minimizing costs or maximizing profits (see Sturm, 1998). The cost and profit function approach presents a more flexible model; however, the application requires much more information such as output and input prices and quantities. Such databases are constructed only in several countries.

Development of multivariate time-series and introduction of VAR (vector-autoregression) into microeconomics by Sims (1980) opened a new chapter in examination of the impact of public-private investment on economic growth. An important contribution was the endogeneity of variables that is inherent in VAR method and the possibility of examination of causality directions between variables. From the 1990s many authors used the VAR method (see Sturm, 1998, Pereira, 2000, Kamps, 2004).

Main disadvantages of VAR methodology are in overparametarization of regression equation and the choice of lag of variables. In addition, this approach requires large data samples for conventional lag lengths. For this reason, most researchers employing the VAR approach have used data on public investments instead of data on the public capital stock. This choice has been dictated not only by the lack of capital stock data for a large number of countries but also by the fact that public investment data are usually available at quarterly frequency whereas public capital stock data are available at annual frequency only. One drawback of this choice is the implicit assumption that the effects of public investments are independent of the level of corresponding capital stock. Economic theory suggests that this assumption is dubious. In spite of these constraints, the analysis of public capital productivity continued to be active area of research (see, Mittnik and Neumann 2001, and Voss 2002). However, VAR approach is not utilized in this research due to short time-span of the data.

Economic models that incorporate spatial effects are becoming increasingly popular. These models have been widely applied in regional science, labor economics, and real estate economics. The estimation of these models is commonly carried out using spatial econometric techniques. However, the large size of many of the data sets has caused significant estimation problems. Techniques have been developed to overcome these estimation problems, including ones that rely on scarcity of spatially-distributed observations. Anselin (1988, p. 8) differs spatial from standard econometric models on basis of more narrow focus on spatial effects – spatial dependence and spatial heterogeneity. One of the harshest criticisms of the spatial econometric models is the use of ad hoc spatial weighting matrices. The criticism stems from the lack of empirical justification for any type of weight matrix in particular and that small changes in the spatial weight matrix often result in changes to the model results. It has been suggested that flexibility needs to be incorporated into the specification of the spatial weight matrix. However, flexibility introduces further estimation issues.

In past two decades a large body of literature on methods for the analysis of panel regression models has emerged. An extensive treatment of methods for panel data

analysis in general can be found in Baltagi (2001) and Hsiao (2003). Most important advantage of panel data sets over cross-sectional or time-series data is in larger number of data points that leads to increased efficiency of econometric estimates.

Finally, the last contribution is towards utilization of the cointegration phenomenon. It is used to analyze the possibility of spurious regressions. Kamps (2004) uses panel cointegration regression to estimate effects of public investments on economic growth on the sample of OECD countries. However, due to the fact that nonstationary panel regression assumes cross-sectional independence these techniques are not used in this research. Such independence assumption is highly unlikely to hold in case of Croatian regions.

However, in spite of these developments, the effects of public investments on output growth are still empirically ambiguous. Extensive reviews of the literature and different methodological approaches are presented by Kamps (2004) and Sturm (1998).

3. Overview of Croatian economy

The starting point of empirical analysis in this research is the year 1997. This is not by accident. Until 1997 the war and hard transitional experiences had their influences on macroeconomic indicators. Inflation was high and therefore any estimation of monetary variables in that period is subject to serious deviations. In this period the privatization process began and had serious flaws starting from the concept that all large companies had to be dismantled or downsized to medium and small enterprises. The accepted view was that only small and medium enterprises can bring prosperity to the economy. Large public enterprises were considered to be remnants of the socialist system that is not fit to survive in a market economy. Such a policy caused a large increase in unemployment and a fall in income, savings, and aggregate demand.

From the year 1997 economic conditions started improving. The consequences of the war slowly receded and the Croatian economy stabilized. Table 1 presents the most important macroeconomic indicators. It can be observed from the data in the table that Croatia had satisfactory macroeconomic indicators in the recent period. Real GDP growth rate was constant over the period 1997-2006 averaging around 4 percent. The only exception was in the year 1999 when the decline of growth was ascribed to financial market instabilities. GDP per capita more than doubled in the period 1997-2006.

At the same time the consumer price index (CPI) remained stable as a result of successful measures taken by the Croatian National Bank (CNB) which set as its main goal the preserving of monetary stability. Any possibility of depreciation of the currency was prevented by sterilization (see the exchange rate dynamics in table 1) of the excess quantity of the Croatian national currency (HRK). However, the goal of stability as the primary goal in developing the economy was often harshly criticized by Croatian economists. CNB saw that issue as a necessary precondition for the EU accession and the growth of the economy. Critics took the position that monetary policy should stimulate

economic growth and that the behavior of the CNB together with the government tax policy divided the functioning of the real and financial sectors of economy. In many ways these sectors function as separate self-sufficient entities.

Considering the gross investments dynamics it can be seen that after 2001 investment activity was substantially higher than before and remained on a high level. This rise is primarily caused by increased investment in the construction sector as a result of government large scale investment in highways. These investments were financed almost exclusively by borrowing. Surprisingly, the government deficit was reduced in spite of increased investments.

Croatia has often been criticized for the large role of the state. Government was not able to reduce spending and reforms toward a more efficient apparatus were slow and without much success. The government's presence in many aspects of economic activity remains significant and is reflected in one of the biggest government sector in the region. At the same time the government is one of the most centralized among European countries. Large government expenditures made necessary a high tax burden which was mainly realized through high VAT revenues but also high level of direct taxation.

The trade balance has a persistent negative trend from the year 1999. The growth of the Croatian economy is ascribed to constant increase of the aggregate demand financed by the increasing debt burden of the population. The question is whether such growth (with a negative trade balance) is sustainable.

An additional problem is caused by high unemployment rates. From the year 2002 this rate was reduced mostly by increased investments. This was especially the case in counties where large construction works occurred (see County of Ličko-Senjska). However, government measures are still inefficient in dealing with this problem.

Although growth rates of the GDP seem to be rather high and stable, the question is whether one should be satisfied with such figures. In the case of a transition economy with high unemployment the rates of growth should be much higher. If unemployment was reduced and borrowing efficiently invested output should be higher. However, this was not the case.

Table 1: Selected macroeconomic indicators in the Republic of Croatia

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
GDP current prices (mil. HRK)	123,811	137,604	141,579	152,519	165,639	181,231	198,422	214,983	231,349	250,590
GDP, current prices (mil. USD)	20,109	21,628	19,906	18,427	19,863	23,021	29,596	35,645	38,882	42,915
GDP constant prices (mil. HRK, 2001)	151,668	155,503	154,164	158,604	165,639	174,809	184,142	192,089	200,284	209,824
GDP real growth rate (in %)	6.8	2.5	-0.9	2.9	4.4	5.5	5.3	4.3	4.3	4.8
GDP per capita, USD	4,398	4,807	4,424	4,153	4,477	5,181	6,663	8,030	8,753	9,664
GFCF* (current prices)	29,952	32,066	33,025	33,281	36,984	44,105	56,662	60,512	65,008	74,792
GFCF (constant prices)	29,952	30,685	29,487	28,373	30,365	34,592	43,122	45,260	47,451	52,596
administrative unemployment rate	16.7	17.2	19.1	21.1	22.0	22.3	19.1	18.0	17.9	16.6
unemployment rate (labor force survey)	9.9	11.4	13.6	16.1	15.8	14.8	14.3	13.8	12.7	11.8
growth rate of real wages	12.1	5.1	9.6	3.9	2.8	3.4	4.0	3.8	1.3	2.1
Net wage in HRK	2,377	2,681	3,055	3,326	3,541	3,720	3,940	4,173	4,376	4,603
Government expenditures/GDP (%)	49.83	52.37	55.19	53.97	50.75	45.3	45.2	43.9	43.4	43.0
general government debt (in % of GDP)	30.00	33.00	42.30	48.90	51.05	50.73	51.12	52.09	52.81	49.67
CPI	3.8	6.0	3.9	5.5	2.4	1.8	1.7	2.7	3.6	2.0
government deficit/surplus (GFS 1986)	-	-	-7.1	-7.5	-6.8	-4.3	-4.8	-4.8	-3.7	-2.8
government deficit/surplus (GFS 2001)	-	-	-	-	-	-3.1	-3.9	-3.8	-2.9	-1.8
population ('000)	4,572	4,501	4,554	4,381	4,437	4,443	4,442	4,439	4,442	4,441
Exchange rate HRK/EUR, period average	6.96	7.14	7.58	7.63	7.47	7.41	7.56	7.50	7.40	7.32
Exchange rate HRK/USD, period average	6.16	6.36	7.12	8.29	8.34	7.87	6.70	6.03	5.95	5.84
Trade balance, mil. USD	-5,120	-3,758	-3,496	-3,455	-4,481	-5,819	-8,022	-8,561	-9,788	-11,112

Source: CNB, CBS, Ministry of Finance

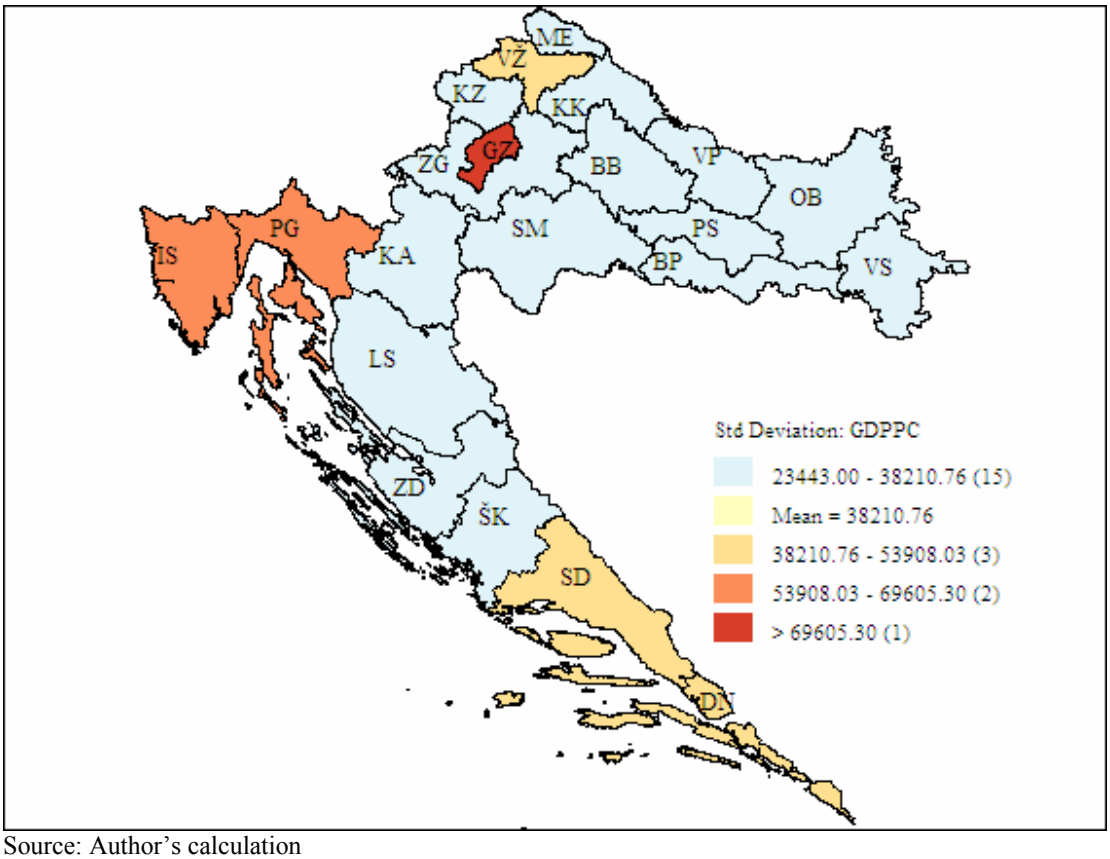
* Gross fixed capital formation, constant prices based on year 1997

4. Economic features of Croatian regions

The reform of the territorial and administrative organization of the public sector in Croatia started in 1994. Twenty counties were formed plus a special area of Zagreb with the simultaneous function of city and county. These counties were organized as classical regions with the function of a midtier of government according to the theory of fiscal federalism. However, from the beginning, this concept was a failure due to fact that these counties did not have financial, technical and organizational resources to support such a function. It is considered that regions have to cover areas between 0,8 to 1,5 million inhabitants in order to function properly as the real middle level of governance. The biggest county (except the City of Zagreb) did not have more than a half million inhabitants. As a confirmation, international statistics did not recognize counties as regions and classify Croatian counties as part of the local sector (see IMF Government Statistics Manual, 2001).

An additional consequence of such a division was a fact well known in the theory of fiscal federalism. A more fragmented system of territorial division makes more unequal units. Such a division in Croatia resulted in several fiscally strong counties and made convergence more difficult to achieve, the reason being that fiscally stronger regions were able to invest more and therefore differences in regional income increased. There were additional problems in regions that were directly involved in war operations. The infrastructure and especially private properties on those areas were greatly damaged. However, government donations for the recovery were substantial. Nevertheless, only one such county increased its income per capita substantially and primarily because of strong construction investments from the year 2001 (Ličko-Senjska county). Figure 1 shows high dispersion of GDP per capita between Croatian counties in the year 2006.

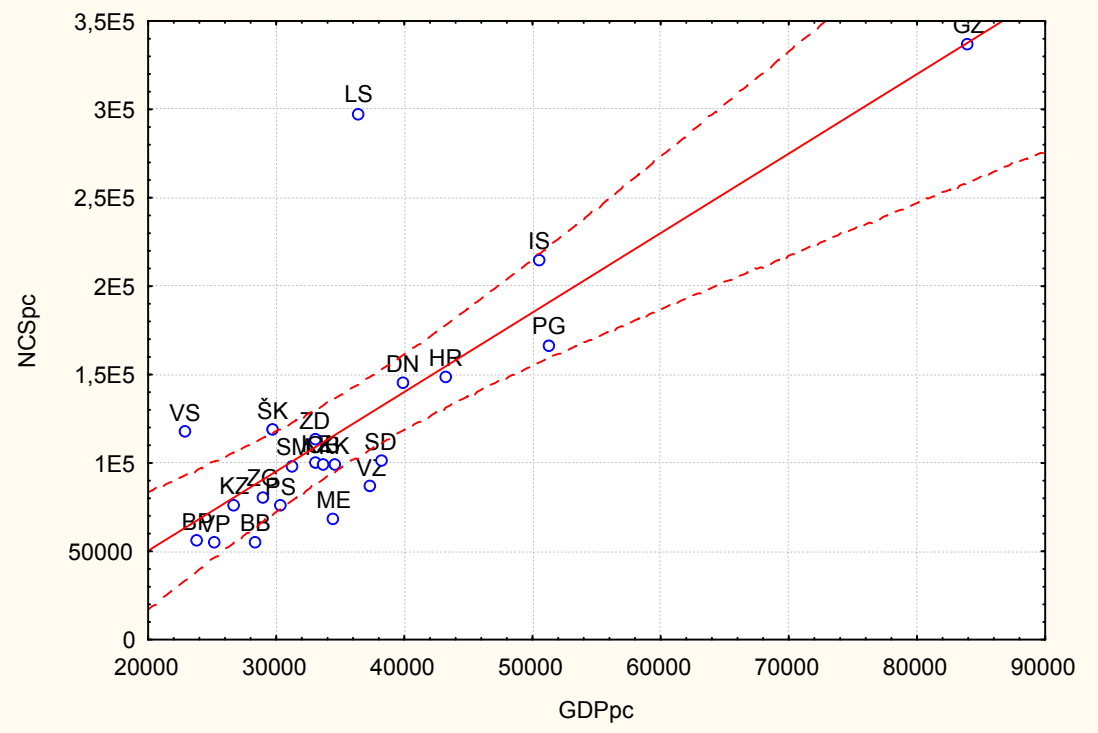
Figure 1: GDP per capita in Croatian counties in year 2006 - standard deviation from the mean



Source: Author's calculation

Table 2 provides more details in the economic condition of Croatian counties. ID attributed to the counties is related to the figure in order to facilitate the spatial comparison of economic indicators. From the data in the table it is obvious that more prosperous regions have better infrastructure, higher employment, and higher wages as well. However, there are some exceptions. There are counties with much higher net capital stocks than the average and also counties that based on their level of development are expected to have higher net capital stocks. This fact is represented in the figure 2 below. However, it can be seen that relationship between net capital stocks per capita and GDP per capita is highly linear for the majority of counties.

Figure 2: Relationship between GDP and net capital stocks per capita in Croatian counties for the year 2006



Source: Author's calculation

An important question arises from this figure. Is economic development a cause or consequence of the long-term investment processes? Nevertheless, there is obvious positive relationship between capital assets and level of output. Infrastructure spending in the short term stimulates temporary boost of wages and employment. That is obvious on the example of county Ličko-Senjska. Unfortunately the time span of the data does not allow the possibility of catching the long term effects. However, it can be observed that the level of employment and wages, after the investment cycle, remained higher than before the investment process started. Indirect effects are already visible in the rise of prices of land surrounding the newly built roads in that county. Entrepreneurial activity also increased. Therefore, "crowd-in" effects definitely did occur.

Table 2: Economic indicators for Croatian counties for the year 2006

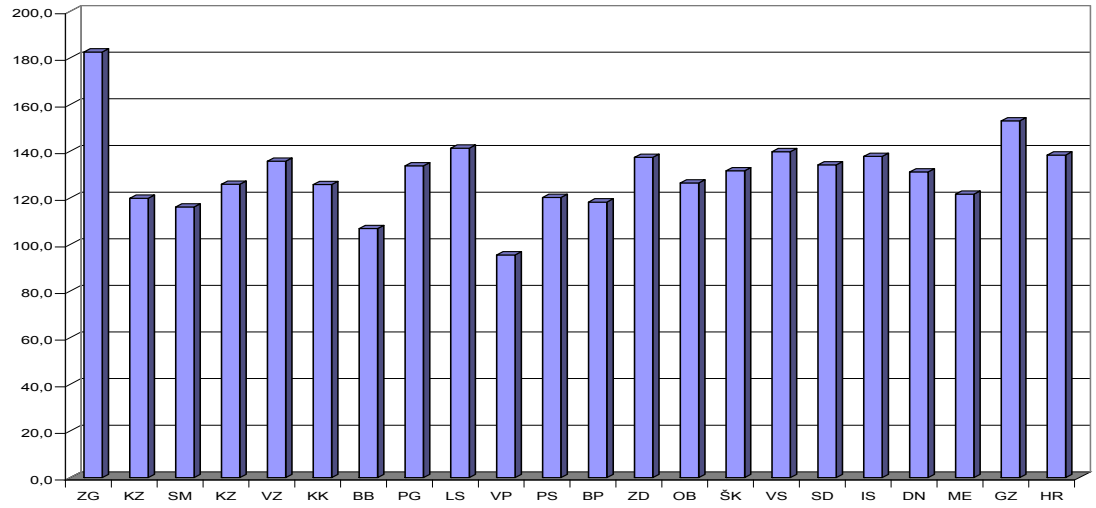
County ID	Counties	population	GDP constant prices (2001)	GDP per capita (in HRK)	average growth rates (1997-2006)	unemployment rate (in percent)	NCS*	NCS per capita	average net wages (2006) - HRK
ZG	Zagrebačka	309696	10350	28912	6,77	18,21	25002	80732	5.028
KZ	Krapinsko-zagorska	142432	4087	26714	1,25	17,69	10817	75944	4.097
SM	Sisačko-moslavačka	185387	6096	31281	2,07	32,71	18175	98036	3.581
KZ	Karlovačka	141787	5050	33127	2,09	30,05	14140	99725	3.879
VZ	Varaždinska	184769	7565	37338	2,63	15,87	15994	86564	3.881
KK	Koprivničko-križevačka	124467	4712	34530	2,06	21,98	12324	99011	3.638
BB	Bjelovarsko-bilogorska	133084	3735	28385	1,24	32,14	7384	55484	3.462
PG	Primorsko-goranska	305505	17676	51262	3,00	15,03	50884	166556	3.670
LS	Ličko-senjska	53677	1627	36467	7,42	26,75	15982	297744	3.719
VP	Virovitičko-podravska	93389	2334	25176	-0,31	37,75	5139	55029	3.589
PS	Požeško-slavonska	85831	2540	30350	4,32	24,93	6501	75746	3.591
BP	Brodsko-posavska	176765	4370	23847	2,87	36,01	9840	55669	4.088
ZD	Zadarska	162045	5654	33019	3,83	24,94	18292	112883	3.468
OB	Osječko-baranjska	330506	11778	33655	2,38	28,66	32776	99168	3.272
ŠK	Šibensko-kninska	112891	3771	29738	3,02	27,84	13406	118753	4.471
VS	Vukovarsko-srijemska	204768	4800	22824	1,60	37,33	24101	117701	4.212
SD	Splitsko-dalmatinska	463676	19026	38183	4,31	25,75	46936	101225	3.791
IS	Istarska	206344	11423	50512	3,95	9,12	44360	214979	4.067
DN	Dubrovačko-neretvanska	122870	5493	39951	2,95	19,62	17842	145209	3.833
ME	Međimurska	118426	4082	34435	3,78	18,99	8102	68418	4.085
GZ	Grad Zagreb	779145	73656	84004	5,48	9,91	262300	336651	4.162
HR	Total	4437460	209824	43288	3,87	20,31	660297	148801	4.411

Source: CBS, Author's calculation

* Net capital stocks (author's data)

As seen from table 2 and it is obvious that there are substantial inequalities between Croatian regions. There are several regions that have an above average income. It was already mentioned that these regions have a much higher capital stock and smaller long-term unemployment. In, addition, these regions except the Ličko-senjska County were traditionally wealthier. Therefore, convergence did not occur. Reasons for the rise of income in the Ličko-senjska County is definitely due to increased investments which on average had a growth rate of 48% in the period 1997-2005. Growth rate of income followed by a 30% increase in the period of highest investment activities. Figure 3 shows different growth dynamics in Croatian regions.

Figure 3: GDP per capita, by counties in 2006 (1997=100)



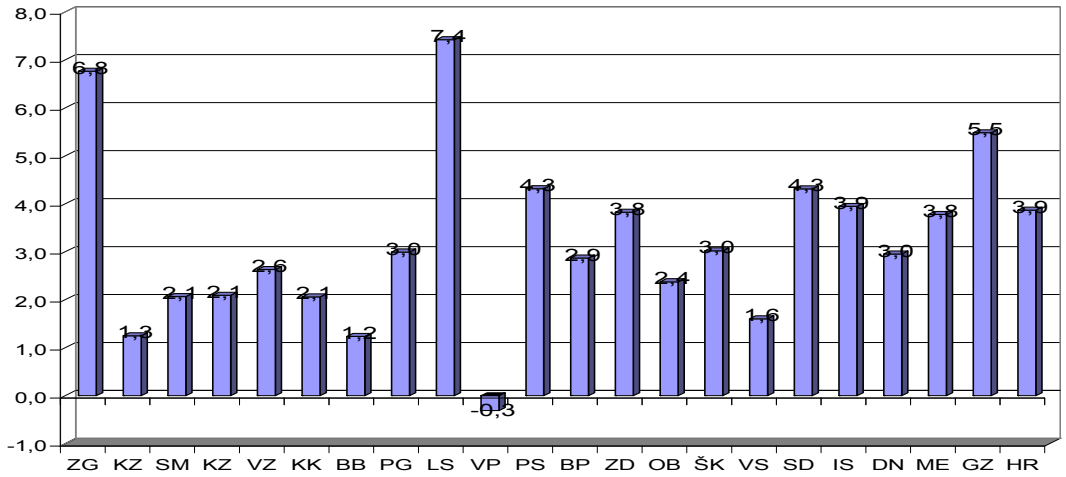
Source: Author's calculation

In spite of the intervention in most advanced economies the economic problem of lagging regions has persisted (see Vickerman, 1991). A similar situation as in case of Croatian regions, with areas suffering from low incomes, high unemployment, low level of capital stocks and high out-migration rates can be seen as a more general pattern. However, in descending from the national to the regional level it is normal to find a certain range of regional values for economic indicators around the national mean. There must always be some regions that are above average and others that are below average. The problem arises if the coefficients of variation are unacceptably high, with per capita income gaps between the poorest and richest region much too wide for social cohesion and stability and if government long-term oriented measures for equalizing such disparities fail (Richardson, 1973). The Gini coefficients show rise of inequality of economic growth between Croatian regions (figure 5).

The Croatian reform of the system of the public sector territorial-administrative division did not follow fiscal federalism principles. The majority of counties formed did not have the economic, social and political background which would justify such a division. It was a decision related to the political goals at that period. But the consequences are similar as the theory suggests – regions were too small to be a significant factor as a tier of government, while the investments of the counties are inefficient and of too small scale.

There is a danger of ineffective regional policies due to expected strong spillover and fiscal leakage effects. The main force on the sub-national level remained in the budget of large cities. Nevertheless, boundaries of regions enabled sub-national investments that have limited scope and, as figure 2 show, wealthier regions invest in their territory and raise their national income, while smaller regions are stuck with their lower level income and investment equilibrium. However, growth rates among regions fluctuate much more than the growth rate of national economy (see figure 4), and given certain favorable background conditions, the will to implement firm policies, and an appropriate scope for regional policy expenditures it is quite feasible to raise a region's rate of growth much more than the national rate. Therefore central government measures towards reviving particular regions have a much greater chance of success than the raising of the national growth rate. An excellent example is again, the county of Ličko-Senjska. Another issue is whether that increased the national welfare. Maybe productivity of public capital is much smaller in that county? Is there a better regional allocation of investments?

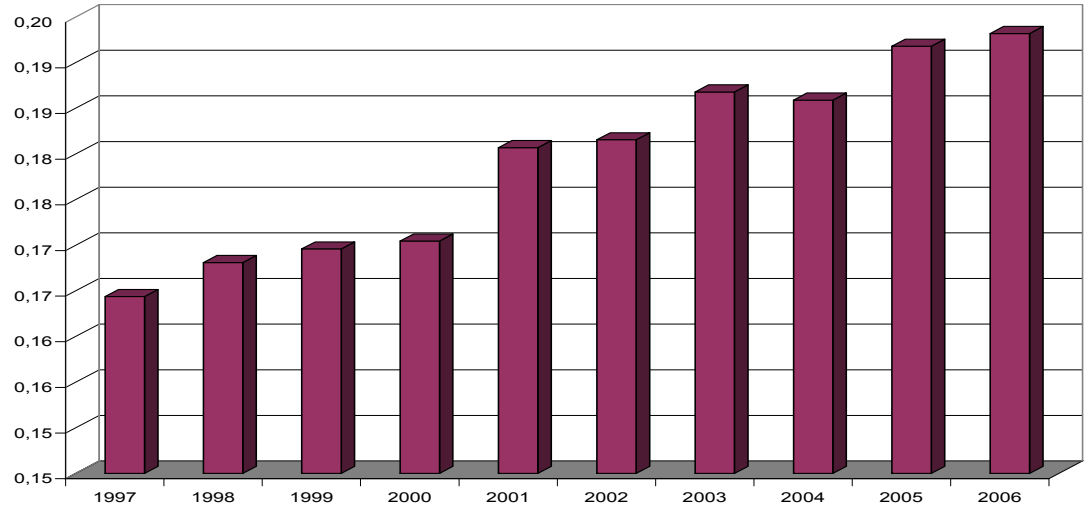
Figure 4: Average real GDP growth rates in the period 1997 – 2006 (in percent)



Source: Author's calculation

Another issue that emerges from the literature, based on the research of capital accumulation effects on economic growth is in distributional effects of investments. Public infrastructure with its features enables a temporary increase of wages and employment and in addition if "crowd-in" of private investment occurs as a consequence there are significant long-term benefits in regional and intraregional income distribution. If that is the case, as a policy measure, this is much better than the usual revenue transfers to the deprived regions and individuals. This is a relatively new area of research and especially important for Croatia due to high income disparities (both of regional income and income of individuals). Figure 5 presents a steady rise of the regional income disparities in Croatia. It demonstrates that regions had different growth rates in the past period and that income inequalities due to that fact increased.

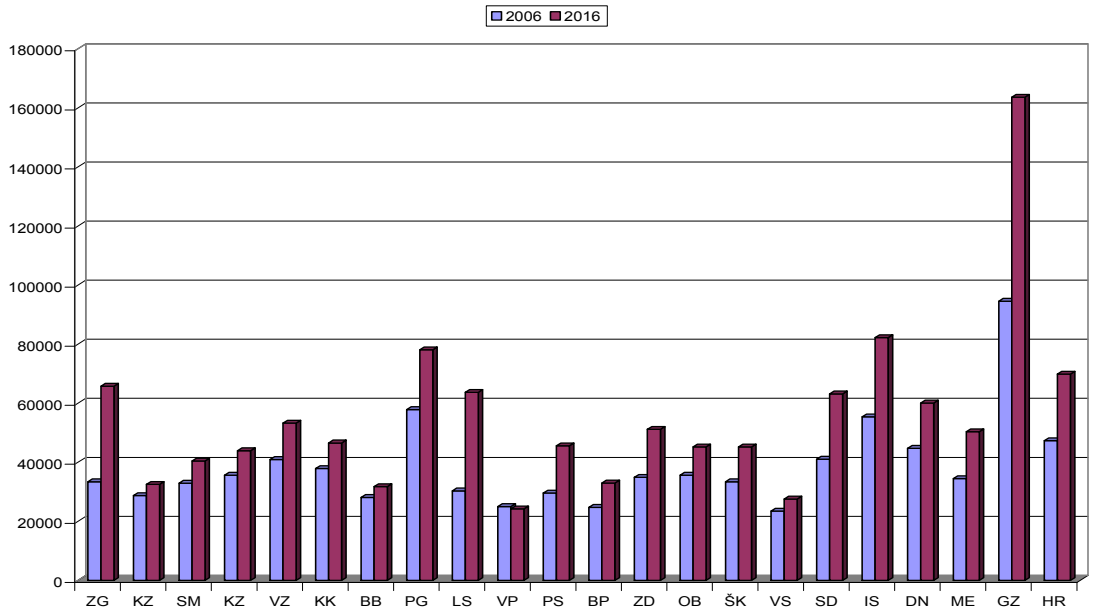
Figure 5: Gini coefficients of GDP per capita in Croatian counties in period 1996-2006



Source: Author's calculation; CBS data on population

Figure 6 shows what will happen in a future period if the government is not able to stop such tendencies. Growth of GDP per capita is calculated by formula $Y = Y_0 e^{rt}$.

Figure 6: Projection of GDP per capita in the year 2016 (in HRK)



Source: Author's calculation

After the brief description of macroeconomic conditions in the Republic of Croatia and also regional economic indicators, a description of the methodology of dataset contruction follows.

5. Methodology of dataset collection and derivation

In this section the methodology for deriving the appropriate dataset for estimation of effects of public capital on economic growth is briefly described. It was already mentioned that one of the crucial reasons for modest volume of empirical research on this issue in most of the countries is in lack of official data. The methodology and data collection process is still troublesome for many national statistics offices. It is not surprising, therefore, that there is no any empirical research on this topic in transition economies. Due to lack of official data on regional capital stocks and GDP, datasets used for estimation in this research had to be indirectly derived.

5.1. Perpetual Inventory Method

Due to fact that Croatian regional capital stocks are derived by utilization of Perpetual Inventory Method (PIM), this method will shortly be described. To use the Perpetual Inventory Method, two assumptions are essential. First, the purchase price of a unit of capital, which is used to weight each unit of capital, reflects the discounted value of its present and future marginal products. Second, a constant proportion of investment in each period is used to replace old capital (depreciation). The first assumption is met if a perfectly competitive capital market exists. The second assumption is fulfilled if accurate estimates of an asset's average service life, discard rate, and depreciation function are available. A frequent criticism of this method is that government is not subject to competitive markets and public goods are not allocated through a price mechanism. A considerable portion of analysis related to economic development is based on a neoclassical production function in which inputs are used up to the point where the value of their marginal product is equal to their cost of use. In such a context, current input capital should be measured as the maximum potential flow of services available from the measured stock. Such a measure of capital can be constructed with the PIM by using a depreciation function that reflects the decline in the asset's ability to produce as much output as when it was originally purchased (Eberts, 1991).

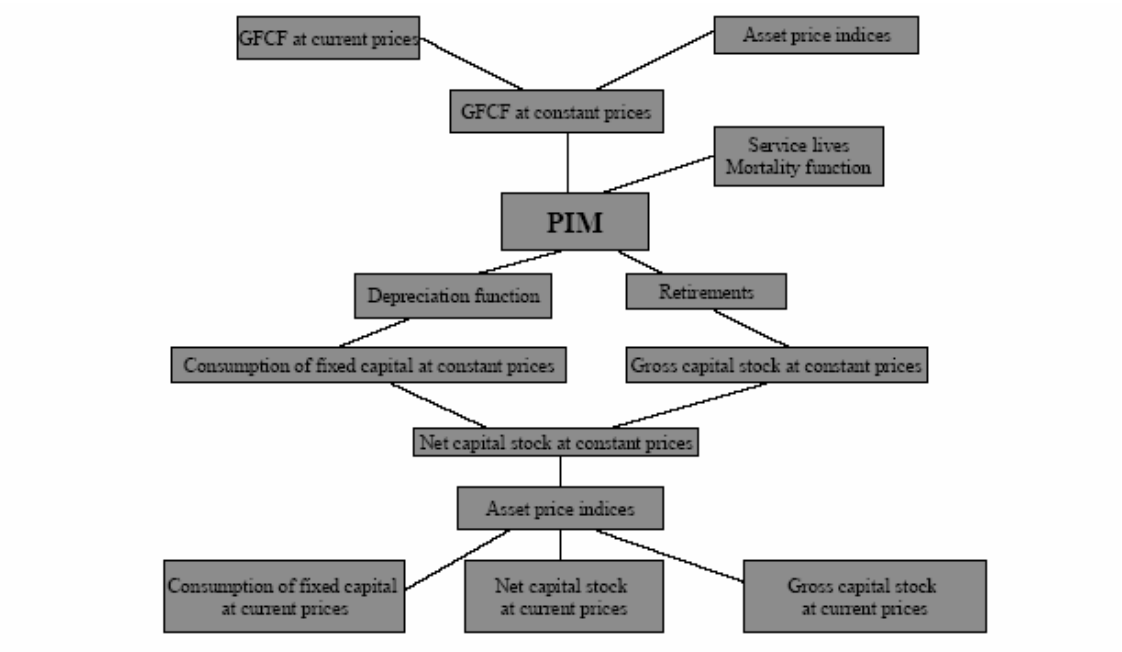
Perpetual Inventory Method is used in numerous research studies that demanded estimation of public and private capital stocks. The methodology applied in estimation of capital stock data is extensively described by OECD (2001) and the U.S. Bureau of Economic Analysis (1999). Some of these studies are in Jacob et al. (1997), Sturm and de Haan (1995), Sturm (1998) who estimate the public capital stock for Netherlands, Munnel (1990), who estimated the capital stock for local and state governments in the United States and Kamps (2004, 2005) for 22 OECD economies.

The standard or traditional approach to using the PIM was to estimate gross capital stock, to apply a depreciation function to calculate consumption of fixed capital, and to obtain the net capital stock by subtracting accumulated capital consumption from the gross capital stock. This approach requires the direct estimation of depreciation from which the

net capital stock is obtained indirectly. The alternative approach[2] is to start by estimating age-efficiency profiles[3] for each type of asset which are then used to generate age-price profiles[4] for assets. The age-price profiles are used to directly estimate the net capital stock from which depreciation is obtained indirectly. This alternative method has an important advantage because by this approach the age-efficiency profiles (used to estimate capital services) determine the age-price profiles (used to estimate the net capital stock and depreciation). Stock and flow data – net stock, consumption of fixed capital, and capital services are based on identical assumptions (age-efficiency profile and discount rate). This is the reason why this method is described as an integrated approach (OECD, 2001).

The application of PIM method requires the following inputs: (1) a time series on gross investment flows, (2) estimations necessitate an initial capital stock (3) an assumption on the size and the time profile of the depreciation rate has to be made, (4) a depreciation method has to be chosen. There are several methods used, linear, geometric and hyperbolic. Usually geometric depreciation is employed. Figure 7 presents application of PIM in practice.

Figure 7: Application of PIM in Practice



Source: OECD, 2001

[2] This method was first applied by United States Bureau of Statistics (BLS), but it is completely applied only by the Australian Bureau of statistics (ABS).
[3] Denotes pattern of capital services that are produced by an asset.
[4] Denotes pattern of asset prices over its service life.

The basic idea of perpetual inventory method is that the net capital stock at the beginning of the following period, K_{t+1}, is the result of the net capital stock at the beginning of the current period, K_t, of gross investment in the current period, I_t, and of depreciation in the current period D_t:

$$K_{t+1} = K_t + I_t - D_t \quad (1)$$

If one assumes geometric depreciation (i.e. stock depreciates at a constant rate, δ), the capital accumulation equation can be rewritten as

$$K_{t+1} = (1 - \delta) K_t + I_t \quad (2)$$

The method is called "perpetual" because all assets are forever part of the inventory of capital stocks. Of course, quantity of services provided by an asset declines as it ages but it never reaches zero. This can be seen by repeatedly substituting the previous equation for the capital stock at the beginning of period t:

$$K_{t+1} = \sum_{i=0}^{\infty} (1-\delta)^i I_{t-1} \quad (3)$$

This expression shows that the capital stock at the beginning of period t+1 is a weighted sum of past investment where the weights are a decreasing function of the distance between the current period and the investment period. In practice, an infinite number of past investment flows is not available so that previous equation is replaced by following expression:

$$K_{t+1} = (1-\delta)^t K_1 + \sum_{i=0}^{t-1} (1-\delta)^i I_{t-1} \quad (4)$$

where K_1 is the initial stock at the beginning of period 1.

An additional step to approximation of real depreciation effects is to divide depreciation of investments in the current year because investment flows are distributed throughout the whole year.

$$K_{t+1} = (1-\delta)^t K_1 + \sum_{i=0}^{t-1} (1-\frac{\delta}{2})^i I_{t-1} \quad (5)$$

By utilizing this equation capital stocks for regions of Croatia are derived.

5.2. Data

All data used for the estimation refer to the time-span from 1997 to 2006. In this research the following datasets will be utilized[5]:

- annual GDP of the Croatian economy,
- annual investments (given by expenditure-based GDP accounting)
- labor of enterprises per counties (small entrepreneurs are excluded)
- average annual wage per counties
- average unemployment per Croatian counties

For the estimation of productivity and spillover effects of public investments in Croatia, data on GDP and net capital stocks had to be obtained. However, until the recent period there were no official data and for a longer time period these data had to be derived. Due to the short-time span of the data and lack of data (doubtful statistics of the earlier years, as well) there is not much research on effects of public investments in Croatia. The fact that Croatia is a newly independent country and had been at war until 1995 resulted in satisfactory datasets only from 1997 to the present. Changes caused by the transition process made it hard to conduct research on macroeconomic indicators. This is especially due to large changes and particularly evident in the case of regional desegregation of macroeconomic indicators. As mentioned, Croatia went through radical administrative-territorial reorganization. In 1994, 21 counties were established and available statistics on such system date only from 1996. Furthermore, changes in statistical standards and methodologies present obstacles in analyzing the time-series data. Till the year 1996 high inflation rate decreased reliability of economic indictors.

Data on investments and labor rely on Croatian national classification of activities. This classification is presented in table 3. It follows the OECD (2001) classification methodology. From that classification, distinction between public and private sector capital stocks can be indirectly derived. However, it is hard to capture sharp distinctions among activities of the private and public sector. Nevertheless, sectoral allocation of production resources regardless of ownership can be useful for analysis. Public sector investments can cover broader or narrower definitions or particular sectors and can be characterized by the mixed presence of the public and private sectors.

[5] Data are available by the author upon a request.

Table 3: Croatian national classification of activities

A	Agriculture, hunting and forestry
B	Fishing
C	Mining and quarrying
D	Manufacturing
E	Electricity, gas and water supply
F	Construction
G	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods
H	Hotels and restaurants
I	Transport, storage and communication
J	Financial intermediation
K	Real estate, renting and business activities
L	Public administration and defense; compulsory social security
M	Education
N	Health and social work
O	Other community, social and personal service activities

Source: CBS

One of the studies on efficiency of investments in Croatia is made by Lovrinčević et al. (2004). They found that it is not the ratio of investments to GDP that is important but rather the efficiency of investments. Their conclusion is based on a dataset of 11 transition economies in the period 1994-2002. The method used is ICOR (Incremental capital-output ratio).[6] Their conclusion is that efficiency of investments depends on structure of investments, i.e. structure of the GDP. ICOR in the sector of services are lower than in the sectors of industry and agriculture. The highest ICOR is on public investments and private housing.

This research partially draws on their methodology in defining public capital. Methodology of defining public investments is briefly described in the text below.

They divide sectors in Croatia into 5 categories:

- private investments within sectors of industry,

It consists of two sectors – the C and D sectors, from which they exclude production of oil and mining of oil and gas (INA – public enterprise[7]).

- private investments in services,

Includes sectors G, H, J, K and O.

[6] ICOR= gross investments in fixed capital in percentage of GDP/growth rate of real GDP. ICOR is used based on the theoretical thesis that it shows reasonable results for middle income countries. ICOR is based on the Harrod-Dommar model of growth – the implicit presumption of that model is that the marginal return of capital is constant and equal to the average return of capital. Therefore the capital coefficient is equal to ICOR, i.e. the reciprocal value of the marginal return of capital.

[7] Entered into the process of privatization in 2005

- investments in agriculture,

Includes sectors A, B. However, they do not distinguish private and public investments in these sectors.

- investments in housing of the households sector
- investments of the government sector and public enterprises.

Investments of the government sector and public enterprises; these investments are in the following categories of Croatian national classification of activities: L – public administration, M – education, N – health and social insurance. Considering these categories it is not possible to completely distinguish public and private investments. Therefore all of the investments in these categories are considered to be public because the public sector dominates, with a 90% share. Public enterprises form public capital as well, sector E – supply of energy, gas and water, category DF-23 (gas derivatives), CA – oil and gas mining. Furthermore, they include the enterprises Croatian Highways and Croatian Roads that form the majority of investments in sector F – construction. Finally sector I – transport, warehouses and communications (Janaf, Jadrolinija, Croatian Post, Croatian railroads, Croatia Airlines, public communal enterprises on local levels etc. is also included in the government sector.

However, in our research the narrow definition of public sector is used. In the aggregate model the following sectors are denoted as public: E, F, I, L, M, and N. The reason for such a distinction is that in those sectors the majority of investments are publicly financed. In part of sectors C and D it is impossible to isolate the public from private capital stock. In addition, public enterprises in C and D sectors are almost completely privatized. The impact of private or public provision in some sectors can only be theoretically analyzed. It is important to mention that many public enterprises are still in the midst of the privatization process. Therefore, the structure of ownership is continuously changing. If it is assumed that the private sector has higher productivity then that would mean that a rise of productivity should influence the output of economy. However, the privatization process in Croatia was heavily criticized, as leading to corruption. It is considered that the government had a goal of obtaining revenues for financing the budget deficit, so it was only interested in short-term revenues from privatization. Many of the privatized companies that were operational under public ownership were liquidated and sold, and the workers left unemployed. Therefore, privatization results are dubious.

In this part, estimation of GDP and net capital stocks are presented. Other datasets used in text are also listed.

Estimation of GDP:

Annual data on GDP for Croatia are provided by the Croatian Bureau of National Statistics. Due to the presence of high inflation, utilization of GDP based on constant prices is reasonable only from the year 1996. Data on GDP per counties is estimated for these years on the basis of proxy – average income per counties obtained by multiplying average wages per counties and labor employed. Justification for such a proxy comes from revenue-based accounting of GDP. Data obtained highly correlate with the official data. Official data exist for the period 2001-2004 and are provided by the Croatian Bureau of National Statistics.

Estimation of capital stocks:

For estimation of capital stocks of the economy and capital stocks by counties PIM methodology is utilized on the basis of data of the Croatian Bureau of National Statistics. The Croatian Bureau of National Statistics has unofficial estimates of capital stocks of the Croatian economy on the aggregate level and for the period 1999-2003.

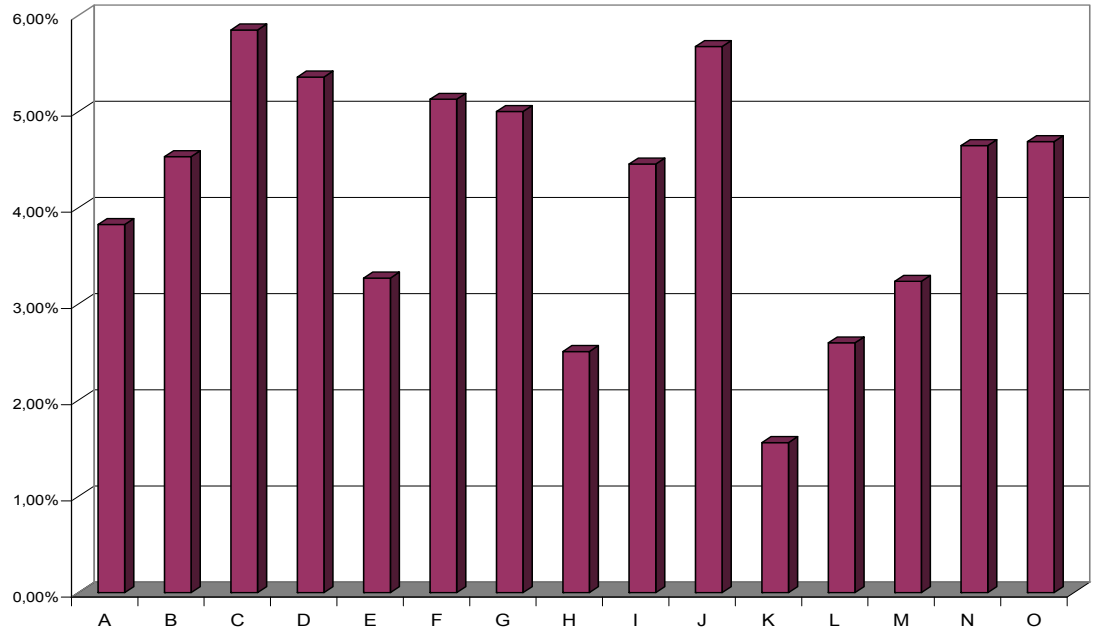
In order to apply the PIM method, it is necessary to have a starting year of net capital stocks, depreciation rate and annual flows of investment (gross fixed capital formation - GFCF). This is a standard approach that can be found in literature in studies that deal with estimating capital stocks.

For initial capital stocks, the year 1999 is used (this is data from the Croatian Central Bureau of Statistics) because the Croatian Central Bureau of National Statistics has estimates on capital stocks only for the period 1999-2003. Since the goal of this research was to provide as long a time-span as could be, in order to be able to conduct econometric analysis, data from 1997-2006 were obtained by forward and backward application of PIM. In empirical research (except for the U.S. economy which has an extensive database on capital stocks), the usual procedure is to obtain data for the first year by employing annual investments as a proxy for the growth rate of capital stocks, and assume a certain depreciation rate. Ashauer (1989, 1990), for example, used a fixed 4% depreciation rate and by sensitivity analysis concluded that the choice of depreciation rate has no significant impact on estimates. However, to be more precise, this research uses depreciation rates that differ for each sector of economy. Depreciation rates are obtained indirectly from the data of the Croatian Bureau of National Statistics and they are based on the structure of assets that are employed in each sector. The depreciation rate necessary for such a calculation is obtained from the depreciation rate by sectors calculated from gross and net capital stocks from the period 1999-2003. The depreciation rate is applied to the geometric rate which is an approach mostly used in literature due to better estimation features than straight-line or hyperbolic rate(see Kamps, 2004).

An important theoretical notion is that all sectors do not use the same structure of assets and therefore depreciation rates have to be different. That could be a source of measurement error reported in previously conducted research (see Baltagi, Pinnoi, 1995, Hsiao, 2001). Another issue is related to that. If data are disaggregated on sectors that use too large or too small a depreciation rate, that could have an important effect on capital

stock accumulation estimates. This is especially true for a sector characterized by large amounts of capital stocks, like manufacturing, for example. Depreciation rates per sectors are presented in the figure 8.

Figure 8: Depreciation rates across the Croatian economy sectors (in percent)



Source: Author's calculation

The labor variable in the production function is presented by using data on labor in enterprises that have more than ten employees (on average this number fluctuates around one million). That means that part of labor is not present – such as private entrepreneurs (about 100 000 employees). However, there is no statistic available that covers the total workforce. Data on labor are also available by sectors, according to NCA.

Data on general government investments and investments of local government units (by counties) are obtained from the database of the Croatian Ministry of Finance. Data on investments of particular public enterprises were not available; however these investments are not expected to be substantial. Ott and Bajo (1999) ascribe a very modest role for public enterprises in the general government investment structure.

The unemployment rate is obtained from statistics on unemployed persons in the period from 1996-2006 by the Croatian Office for Labor Employment. However, statistics on labor unemployment are dubious. The existence of a grey economy implies that caution must be exercised in presenting the unemployment rate as a proxy for the business cycle. In addition, the rate of unemployment in some periods was artificially reduced by administrative decisions and measures.

6. Estimation of capital accumulation effects on economic growth

For the purposes of estimation several models based on theoretical assumptions are used. All models are based on the log-linear specification of the Cobb-Douglas function. Arguments used in explaining similar specifications can be found in many of studies that use this form of production function such as Aschauer (1989), Baltagi, Pinnoi (1995), Kamps (2004), Sturm (1998). Model in three level of aggregation is presented below.

Model 1:

$$Y_{it} = \alpha + \beta K_{it} + \beta_1 KG_{it} + \beta_2 l_{it} + \beta_3 Un_{it} + \beta_4 Dummy_{it} + u_{it} \quad (6)$$

Model 2:

$$Y_{it} = \alpha + \beta K_{it} + \beta_1 KPG_{it} + \beta_2 KSG_{it} + \beta_3 l_{it} + \beta_4 Un_{it} + \beta_5 Dummy_{it} + u_{it} \quad (7)$$

Model 3:

$$Y_{it} = \alpha + \beta K_{it} + \beta_1 KEG_{it} + \beta_2 KFG_{it} + \beta_3 KIG_{it} + \beta_4 KSG_{it} + \beta_5 l_{it} + \beta_6 Un_{it} + \beta_7 Dummy_{it} + u_{it} \quad (8)$$

where $u_{it} = \mu_i + \nu_{it}$. These models are estimated by using different specifications of the error term. After that appropriate testing of the efficiency of particular specifications is conducted.

Variable Y denotes the GDP for Croatia and by counties as well. K denotes private capital accumulation, KG public sector capital, l labor and Un unemployment rate. Models 2 and 3 disaggregate public sector capital into KPG – "physical government capital" (sectors E, I, F) and KSG - "social government capital" (sectors L, M, N). The third model further disaggregates public sector physical capital where KEG stands for physical capital in the sector of electricity, gas and water supply, KFG – physical capital in the construction sector, KIG – physical capital in the sector of transport, storage and communication.

The cross section time series dimension enables econometric estimation of small time series by utilization of the cross-section dimension of data. It is important to say that the error term u_{it} in the models consist of term γ_{it} which stands for the state-specific effects and term υ_{it} for random disturbance. Depending on the treatment of the γ_{it} part of the error term panel regression measures regression within the groups (fixed effects regression or state-specific) or between the regressions means (between regressions). Random GLS regression is calculated as the weighted average of the between and fixed

estimator. Finally, for the difference from the other usual models, a dummy variable is used in order to control for the negative growth rates of GDP in the year 1999. This was necessary due to the fact that this reduction of GDP was not caused by the investment reduction but instead by factors within the financial conditions in the country. In addition, the unemployment rate did not follow such a reduction of GDP and therefore the need for introduction of a dummy variable was justified.

Distinction between public sector physical and social capital is made by the theoretical features of these types of public sector investments. Investment in physical capital is more directly related to an increase of the productivity of the private sector and has direct impact on employment, wages and output. Investments within the social capital sectors are expected to have longer gestation periods and it is therefore unlikely to be able to catch their effects on output (which has more indirect impact). In addition, part of these investments is related to support of the public administration process (still large and inefficient) and therefore it is expected to have lesser effects on output growth.

These basic models are tested in the framework of different econometric methodologies, with tests that are important for the reliability and robustness of the estimates.

6.1. Estimation efficiency testing

Pooled OLS, fixed (within), between and random estimations of the models are performed. The important issue is which of the estimators is most efficient. First the justification of the pooling of the data is given. This is done by using the popular Chow test. Besides that Hausman and Breusch and Pagan LM test are performed. These tests are usually used to determine which of the estimators, random or fixed, is more efficient.

The difference between the fixed (within) and random estimator is that fixed regression allows the correlation with the error term by using the dummy variables that control for the, in this case, county specific observations. Therefore, within estimation is less efficient because use of information by that procedure is suboptimal. Random effect estimator assumes that there is no correlation with specific individual observations and the error term. In that way a county-specific error term can be included in the model and results will be more efficient. Some authors prefer a fixed and others prefer a random estimator. For example, Garcia-Mila and McGuire (1992) reject controlling for state effects in order that the cyclical variation over time neutralizes the long-run relationship. The fixed-effects estimator will provide consistent estimates, but these estimates will exploit only the time or “within-state” variation in the data.

Poolability test

The question whether it can be justified to pool data is resolved by determining whether regression coefficients vary from year to year from the regression estimated on the total time-period of the data set. The Poolability test is performed by using the Chow test. It is

done by running the individual regressions for the time period and comparing the results with pooled regression. The general form of the Chow test is (see Baltagi, 2005, p. 54):

$$F_{obs} = \frac{\left(e^{'}e - e_1^{'}e_1 - ... - e_N^{'}e_N\right)/(N-1)K^{'}}{\left(e_1^{'}e_1 + e_2^{'}e_2 + ... + e_N^{'}e_N\right)/N(T-K^{'})} \tag{9}$$

Under the H_0 F_{obs} is distributed as an $F((N-1)K^{'}, N(T-K^{'}))$

The F-test for all three models is significant with the resulting values of 20.94 for the model 1, 18.24 for the model 2 and 19.59 for the model 3. Therefore, it can be concluded that time-series dimension of data can be pooled and there are no structural breakpoints.

LM Breuch and Pagan test

To test whether the "state specific" effects are correlated with the explanatory variables in the model, Breuch and Pagan (1980) developed a Langrage multiplier test for the random effects model based on the OLS residuals.

General form of the LM test is as follows (see Green, 2002, p. 298):

$$LM = \frac{nT}{2(T-1)}\left[\frac{\sum_{i=1}^{n}\left[\sum_{t=1}^{T}e_{it}\right]^2}{\sum_{i=1}^{n}\sum_{t=1}^{T}e_{it}^2} - 1\right]^2 \tag{10}$$

where

$$H_0 : \sigma_u^2 = 0 \tag{11}$$

$$H_1 : \sigma_u^2 \neq 0 \tag{12}$$

Under the null hypothesis, LM follows chi-square distribution with one degree of freedom. Although this test is often used in choosing the random or fixed regression model, Kennedy (2003) warns that this is not appropriate. It is only used to test for the significance of the individual (cross-section specific) observations.

Hausman test

The Hausman (1978) test is often used in the empirical research conducted by using cross-section time-series regressions. The idea for the test comes from the assumptions of the fixed and random effects models. The fixed model allows the unobserved individual effects to be correlated with the included variables. On the other hand, if the individual effects are not correlated with the regressors it is more appropriate to model the individual specific constant term as randomly distributed across cross-sectional units. The Hausman test relies on the idea that under the hypothesis of no correlation both random and fixed estimators will be consistent but the random effects model will be efficient.

Under the null hypothesis of no correlation the two estimates should not differ systematically and the random effects estimator would be more efficient. Therefore it follows (see Green, 2002, p. 302):

$$Var\left[(b-\hat{\beta})\right] = Var[b] + Var\left[\hat{\beta}\right] - Cov\left[b,\hat{\beta}\right] - Cov\left[b,\hat{\beta}\right] \quad (13)$$

The test relies on the hypothesis that the difference of the covariance of an efficient estimator and covariance of the inefficient estimator is zero:

$$Cov\left[(b-\hat{\beta}),\hat{\beta}\right] = Cov\left[b,\hat{\beta}\right] - Var\left[\hat{\beta}\right] = 0 \quad (14)$$

or

$$Cov\left[b,\hat{\beta}\right] = Var\left[\hat{\beta}\right] \quad (15)$$

Inserting the last expression in the first equation we get

$$Var\left[(b-\hat{\beta})\right] = Var[b] - Var\left[\hat{\beta}\right] = \varphi \quad (16)$$

The test of significance is based on the Wald test and follows chi-square distribution with K – 1 degrees of freedom:

$$W = \left[b-\hat{\beta}\right]' \varphi^{-1} \left[b-\hat{\beta}\right] \quad (17)$$

6.2. Estimation results

Table 4 shows the estimation results using models (6), (7) and (8) for the period between the years 1997 and 2006. The Hausman and Breusch and Pagan LM tests were performed. The LM-test showed in almost all models that there are significant individual effects that are correlated with the OLS residuals. The Hausman test confirmed the results and the fixed (within) effects estimator is considered to be consistent unlike the random estimator. However, both of the tests gave similar results.

The estimated coefficient in the table shows positive short-term effects of the public investments especially in the sector of construction and transport. According to results, in short run 1% increase in public investments increases output for 5,7%. 1% increase in the category of infrastructure construction and investments in transport increase output for 2,8% and 7% respectively. Effects of the public social capital are ambiguous which is expected in the short term due to long gestation period of effects of such type of investments. These results are similar as in Baltagi (1995) who argues that such results could be due to excess capacity of school buildings and fact that facilities are not good indicator for health and education services. One possible reason for ambiguous results in estimation of social capital within the Croatian dataset could be in fact that too large

public administration in country could offset positive effects of other activities included in that category of capital. Private capital positively contributed to output growth both in short and longer time period. However, rates of return are much higher in the short term. Between estimators shows the long run relations and indicates the positive contributions of private and public capital. However, when public capital is disaggregated, only the coefficient of public physical capital remains positive and significant (and the sector of transport too). The labor factor increase has, as expected, positive impact on the output growth in all of the models.

Table 4: Estimation results for the period 1997 - 2006

Dependent variable: ln (GDP)	Number of observations: 210											
Variables	**Pooled OLS**			**Within**			**Between**			**Random GLS**		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	-2.157809* (-26.65)	-2.211451* (-28.60)	-1.968712* (-25.50)	-5.495501 (-6.46)	-5.706647* (-5.63)	-3.709465* (-3.51)	-2.181324* (-12.49)	-2.215721* (-14.41)	-1.959421* (-12.92)	-2.079012* (-12.16)	-2.197386* (-14.36)	-1.976003* (-13.66)
K	.0436518* (2.80)	.0652543* (4.37	.0637732* (4.36)	.309442* (6.41)	.25572* (4.02)	.1598871** (2.30)	.0491221 (1.42)	.0634576*** (2.11)	.0543059*** (1.85)	.0805211* (2.74)	.0935648* (3.28)	.0724541* (2.73)
KG	.0946925* (8.26)			.0571887* (2.72)			.0699821** (2.49)			.1262555* (7.93)		
KPG		.0840126* (11.88)			.039373* (2.73)			.0723932* (4.17)			.0915206* (9.94)	
KSG		-.0597507* (-3.77)	-.0698474* (-4.76)		.0849341 (1.05)	.0598863 (0.75)		-.0544306 (-1.65)	-.0411449 (-1.28)		-.0635484** (-2.20)	-.0646522* (-2.54)
KEG			.024721** (2.60)			-.032167 (-1.23)			.0332169 (1.67)			.0155989 (1.02)
KFG			.0249829* (6.85)			.0281891* (4.31)			-.0030776 (-0.24)			.033491* (8.42)
KIG			.049808* (7.60)			.0704351* (2.94)			.0471039* (3.61)			.0522448* (4.48)
L	.9128377* (63.92)	.9563072* (66.39)	.9432688* (69.03)	1.021112* (11.88)	1.043809* (11.85)	.9490684* (11.34)	.9311215* (30.13)	.9638894* (33.52)	.9432149* (35.09)	.8461571* (29.43)	.9256022* (33.45)	.9304145* (36.72)
Un	.0008238 (1.52)	.000517 (1.09)	-.000224 (-0.48)	.0042578* (3.26)	.004128* (3.06)	.0016143 (1.19)	.0003309 (0.26)	.0000815 (0.08)	-.0006114 (0.554)	.0012528 (1.53)	.0011196 (1.54)	.0003483 (0.51)
Dummy	-.0628349* (-4.64)	-.056097* (-4.66)	-.0538568* (-4.86)	-.0466678* (-4.80)	-.0467842* (-4.82)	-.0468208* (-5.18)				-.0554686* (-5.16)	-.0527432* (-5.09)	-.0493265* (-5.32)
R-square	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
LM test										86.13*	46.13*	66.61*
Hausman test										155.81*	44.14*	114.25*

Source: Author's calculation

t- values are in parentheses; *, ** and *** denote statistical significance at the 1%, 5% and 10% level

6.3. Restricted estimation – assumption of linearity

Assumption of linearity of the production function variables does not change the values of the estimated coefficients. In comparison with the unrestricted estimation of the same period it only reduces the elasticity of the labor factor.

Table 5: Estimates under the assumption of constant returns to scale of production factors

Dependent variable: ln (GDP)			Number of observations: 210	
Variables	**Pooled OLS**	**Within**	**Between**	**Random GLS**
Constant	-1.537501* (-65.90)	-1.275704* (-21.89)	-1.56682* (-26.16)	-1.437645* (-34.04)
KG/K	.0945963* (7.23)	.1070115* (5.46)	.0680138*** (1.85)	.1293281* (7.67)
l/K	.8418266* (66.42)	.6324686* (16.70)	.8618347* (26.93)	.7559057* (30.59)
Dummy	-.062205* (-4.03)	-.0492048* (-4.77)		-.0538595* (-5.01)
Un	-.0013174* (-2.47)	-.0006351 (-0.70)	-.0020363 (-1.43)	-.0000995 (-0.13)
R-square	0.96	0.95	0.95	0.95
LM-test				35.80*
Hausman test				194.01*

Source: Author's calculation
t- values are in parentheses; *, ** and *** denote statistical significance at the 1%, 5% and 10% level

6.4. Comparison of different data sources

GDP estimates of the Central Bureau of Statistics were available for the years 2001 to 2004. Due to fact that estimation of the GDP of the Croatian regions in this paper for the years between 1997 and 2006 relies on the proxy (product of labor and wages) some bias is expected to occur. If the growth of labor increased GDP estimates more than the growth of real wages (which is expected for the Croatian economy), there will be a bias toward higher elasticity of output on growth of the labor factor. That assumption is confirmed by the estimation of these different data sources. Accordingly, this bias will work also on the opposite side. Private and public capital is expected to have lower coefficient values then the ones estimated from the CBS database. It is logical that private capital values are even more biased in these years because government expenditures in the sector of construction (F) were especially high and significantly raised the employment rate in counties where the majority of construction occurred. Reduction of unemployment is also observed in surrounding counties which indicates the possibility of high spillover effects.

As expected, the estimated coefficients of productive capital net stocks are positive and significant in both datasets. The LM and Hausman tests reject the null hypothesis of no correlation between the individual county effects and the error term. This means that fixed effects estimator is more efficient. In addition, the construction sector growth of stocks is found to be positive for the growth rate. However, only the short-term effects can be captured in this period.

According to the assumption of biased estimates of GDP, it can be seen that estimation based on the GDP data of the Central Bureau of Statistics gives higher values of estimated coefficients on public sector investment. Especially high elasticity coefficients can be observed for the private capital and construction sector as the category of the public capital (F sector). Social public capital in the fixed effects estimation has a surprisingly high coefficient but on the other side the random estimator finds significant and negative elasticity. It is not possible to determine more efficient estimator by the Hausman test because the test was not possible to compute due to negative variances. That could be due to a small sample and a short time period.

It is interesting to compare results of estimation presented in table 4 with estimation of shorter time periods reported in tables 6 and 7. It can be noticed that estimated coefficients for public physical capital and construction investments are much higher if we use time period 2001-2004 instead longer time period 1997-2006. Short run increase of public physical capital by 1% in period 2001-2004 leads to 13,6% of output increase if we use author's data. Such increase in period 1997-2006 is much lower and equals 4% (table 4). Same situation is in case of construction investment where output increases for 6,9% in table 11 and 2,8% in case of longer sample in table 4. Difference in coefficients are much higher when we compare author's dataset in period 1997-2006 in table 4 with estimation on the bases of CBS official dataset in table 7. Estimated short-term effects presented by coefficient values of 1% increase of physical public sector capital and government construction investments leads to 27% and 13,7% increase of output respectively. Such differences in coefficients, when time period analyzed changes, show how sensitive estimated coefficients are in terms of the time series feature of the sample. That is a confirmation of different rates of return on investments in time.

Decrease of output elasticity on labor factor when we use time period 2001-2004 was expected due to fact that before year 2001 the rate of unemployment was constant and high. Results of the estimation with the CBS dataset do not show short-term significant relationship of employment and growth. However, between estimation shows significant and positive relation. That could be explained due to fact that growth of the labor force is lagged and follows one or two year after the investment process began.

Incredibly high short-term rates of return on the social capital investments when using the official datasets are not easy to explain. There is a possibility of inconsistent estimation. In addition, random effects estimation show significant negative values for the same category. This could be a consequence of small sample used in this comparison.

Table 6: Estimation results – dataset 2001-2004, author's GDP estimates

Dependent variable: ln (GDP)	**Number of observations: 84**											
Variables	**Pooled OLS**			**Within**			**Between**			**Random GLS**		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Constant	-1.995288* (-21.31)	-2.009886* (-21.64)	-1.759953* (-18.71)	1.700042 (0.97)	1.251326 (0.59)	3.105876 (1.33)	-2.011466* (-12.68)	-2.029441* (-14.03)	-1.763243* (-12.34)	-1.924356* (-12.31)	-1.946555* (-13.13)	-1.738289* (-11.61)
K	.0516002* (2.79)	.0645235* (3.51)	.0519513* (2.83)	.1484878 (1.19)	.0431223 (0.30)	-.0115074 (-0.06)	.0473912 (1.49)	.0624608** (2.17)	.0511585*** (1.83)	.0680925** (2.34)	.0695946** (2.39)	.0524238*** (1.78)
KG	.0947657* (6.43)			.1820139* (3.89)			.0958262* (3.76)			.092446* (4.13)		
KPG		.0805095* (8.05)			.1356313* (3.88)			.0836964* (5.16)			.0752719* (5.17)	
KSG		-.0255425 (-1.32)	-.034658*** (-1.90)		.1712506 (0.90)	.0579667 (0.31)		-.0334825 (-1.09)	-.0353818 (-1.25)		-.0085625 (-0.29)	-.0269572 (-0.95)
KEG			.0460032* (3.79)			.049195 (0.54)			.0484109** (2.62)			.0418185** (2.16)
KFG			.0113109*** (1.94)			.0689519* (4.84)			.0068246 (0.69)			.0184199** (2.39)
KIG			.0471457* (5.64)			-.0160077 (-0.19)			.0474237* (3.76)			.0468504* (3.47)
L	.8951405* (53.47)	.9192915* (53.41)	.9068508* (54.97)	.3966269*** (2.87)	.45066*** (3.35)	.4422334* (3.53)	.8993708* (32.01)	.9264999* (34.43)	.9095622* (36.23)	.8762852* (30.64)	.9003612* (33.03)	.8967034* (34.18)
Un	-.0000554 (-0.09)	-.0000267 (-0.05)	-.0004988 (-0.91)	-.0044668* (-1.79)	-.0038002 (-1.46)	-.0037595 (-1.51)	-3.64e-06 (-0.00)	-.0001018 (-0.11)	-.0005555 (-0.64)	-.0002411 (-0.28)	.0000132 (0.02)	-.0002865 (-0.36)
R-square	0.99	0.99	0.99	0.99	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99
LM test										21.90*	10.06*	4.58*
Hausman test										13.56*	15.21*	21.73*

Source: Author's calculation

t- values are in parentheses; *, ** and *** denote statistical significance at the 1%, 5% and 10% level

Table 7: Estimation results – dataset 2001-2004, CBS GDP estimates

Dependent variable: ln (GDP)				Number of observations: 84								
Variables	**Pooled OLS**			**Within**			**Between**			**Random GLS**		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	-.2569474 (-0.88)	-.4251426 (-1.39)	-.4242231 (-1.32)	-6.849828 (-1.56)	-13.48526** (-2.59)	-11.5233*** (-1.97)	-.5290248 (-1.35)		-.4966968 (-1.19)	.508997 (1.00)	.119942 (0.22)	-.0762012 (-0.14)
K	.102019*** (1.76)	.1463975** (2.42)	.1092422*** (1.74)	1.543168* (4.89)	1.082113* (3.08)	1.026885** (2.28)	.1050374 (1.33)	.1287076 (1.55)	.0679238 (0.83)	.1122678 (1.18)	.2131987** (1.99)	.1878262*** (1.75)
KG	.1018457** (2.21)			.3784103* (3.21)			.0859643 (1.36)			.1454645** (1.98)		
KPG		.1063389* (3.23)			.2707072* (3.16)			.0830202* (1.78)			.1480656* (2.87)	
KSG		-.115585*** (-1.82)	-.1349266** (-2.17)		1.209323* (2.59)	1.078798* (2.27)		-.06214 (-0.70)	-.0665606 (-0.80)		-.2136583** (-1.96)	-.2132515** (-2.08)
KEG			.1242493* (3.00)			-.0128043 (-0.06)			.148627** (2.75)			.0959334 (1.37)
KFG			.0400755* (2.01)			.1366882* (3.82)			-.0051072 (-0.18)			.0960116* (3.64)
KIG			-.016741 (-0.59)			.0900127 (0.43)			-.0150992 (-0.419			-.0178135 (-0.36)
L	.7148901* (13.67)	.7772217* (13.73)	.8045618* (14.26)	-.1202104 (-0.35)	.1307422 (0.40)	.1560146 (0.50)	.7427365* (10.67)	.7803642* (10.06)	.8012362* (10.91)	.6192346* (6.64)	.7250549* (7.26)	.7579645* (7.99)
Un	-.0063132* (-3.34)	-.0062247* (-3.42)	-.0047759** (-2.56)	-.0153603* (-2.45)	-.010528 (-1.65)	-.0100781 (-1.61)	-.0033037 (-1.25)	-.0034222 (-1.31)	-.0020568 (-0.81)	-.0141976* (-4.98)	-.0131254* (-4.70)	-.0097593* (-3.45)
R-square	0.97	0.97	0.97	0.88	0.90	0.90	0.97	0.97	0.97	0.96	0.97	0.97
LM test										4.45*	4.75**	3.50***
Hausman test										222.46*	-315.93	-1.01

Source: Author's calculation

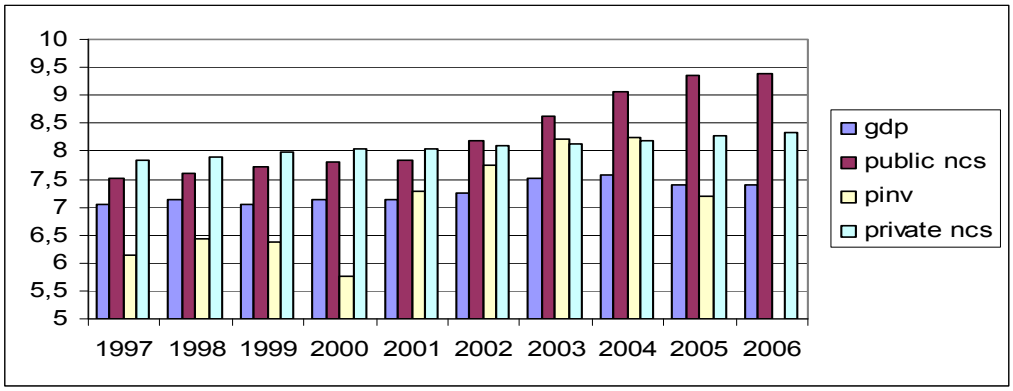
t- values are in parentheses; *, ** and *** denote statistical significance at the 1%, 5% and 10% level

6.5. Measurement error

In order to test possible measurement error some authors use differencing schemes (see Griliches and Hausman, 1986, Baltagi and Pinnoi, 1995). It is thought that if the estimated coefficient varies significantly then there is a possibility of measurement error. According to the data in the table 8 that hypothesis cannot be rejected. In addition negative estimates of private capital warn on the possible GDP bias. However, these estimates demonstrate the possibility that private capital investments in Croatia had labor-displacing features (which is not surprising).

An additional problem comes from the fact that increases in investment boosts short-term economic indicators. Therefore, decreases in investments reduce the temporary high level of employment and rise of wages and, therefore, county GDP. Because of that it is expected that there would be a high correlation between investments and GDP growth. That short-time relation imposes problems when measuring the effects of capital accumulation by using net capital stocks. The reason is that net capital stocks do not follow the same dynamics as investments. Investments are added in the net capital stocks every year and they could have the pattern of a stationary variable (especially in the case of regions where investments are often financed from the national level of government). On the other hand capital net stock formation follows the time trend in which, in the case of a reduction of investment their value decays slowly. In the first years after the investments are reduced it is possible that they still have a growth trend, i.e., they could have opposite dynamics. Therefore it is possible that short-term and long-term effects are mixed and estimates are inefficient. Numerous studies that dealt with the estimation of output growth by using the capital stocks derived by the perpetual inventory method do not mention such a possibility. The confirmation for such a thesis is presented by figure 9 where dynamics of the log values of GDP, public and private net capital stocks, and public investment in the county of Ličko-Senjska are compared. It is obvious that public net capital stock and public investments do not follow the same dynamic from the year 2003. The direct consequence of such dynamics is that usage of capital stocks for the estimation of the short-term relations to GDP growth could result that estimated coefficient values on capital inputs are much lower from the actual rates of return on public sector investments.

Figure 9: Relation of dynamics of GDP, public and private sector net capital stocks, and public investments for the County of Ličko-Senjska (in logs)



Source: Author's calculation

Table 8: Difference estimator and the measurement error

Dependent variable: ln (GDP)	Number of observations: 189, 168, 147, 126											
Differences	**First**			**Second**			**Third**			**Fourth**		
Variables	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Constant	.0325547* (7.00)	.0329082* (6.84)	.0316281* (6.51)	-.0025955 (-0.76)	-.0018864 (-0.55)	-.0000755 (-0.02)	.0015293 (0.24)	.0010012 (0.16)	-.0011226 (-0.18)	-.0154424 (-1.27)	-.0149879 (-1.23)	-.0230609 (-0.78)
K	-.3283491* (-3.54)	-.300544* (-3.09)	-.3317448* (-3.42)	-.6289761* (-4.45)	-.5923591* (-4.09)	-.5945367* (-4.14)	-.7238117* (-4.20)	-.6714861* (-3.77)	-.6772568* (-3.83)	-.8154611* (-3.959	-.7924916* (-3.70)	-.8143851* (-3.69)
KG	.0174841 (0.52)			.0694433 (1.22)			.1741205** (2.22)			.2512064* (2.78)		
KPG		.018114 (0.85)			.0649288*** (1.84)			.1232521** (2.55)			.1576813* (2.77)	
KSG		-.1213426 (-1.04)	-.1195145 (-1.02)		-.2045688 (-1.05)	-.2275495 (-1.17)		-.1807096 (-0.73)	-.1900171 (-0.76)		.0265774 (0.09)	.003446 (0.01)
KEG			-.0254392 (0.91)			.0106858 (-0.25)			-.0263715 (-0.38)			-.1453237 (0.620)
KFG			.0250058* (2.99)			.0285445** (2.44)			.0401685* (2.84)			.1116394** (2.32)
KIG			-.0014541 (-0.05)			.0668244 (1.28)			.1867101** (2.39)			-.1666304 (-0.61)
L	.6471282* (8.78)	.6406401* (8.73)	.6280947* (8.76)	.5899241* (8.53)	.5898305* (8.62)	.5998621* (8.81)	.5809352* (8.45)	.5857125* (8.58)	.6094411* (8.85)	.5974553* (8.67)	.6043867* (8.77)	.6219254* (8.71)
Un	-.0014249 (-1.11)	-.0015376 (-1.19)	-.0019438 (-1.49)	-.0040366* (-2.64)	-.0040247* (-2.65)	-.0040086* (-2.67)	-.004336* (-2.51)	-.0044164* (-2.56)	-.0047773* (-2.81)	-.0049512* (-2.67)	-.0049769* (-2.67)	-.0042512* (-2.27)
R-square adj.	0.52	0.52	0.53	0.50	0.51	0.52	0.50	0.50	0.52	0.51	0.50	0.49

Source: Author's calculation

t- values are in parentheses; *, ** and *** denote statistical significance at the 1%, 5% and 10% level

6.6. Long-differences estimation

In order to determine long run relations and prevent the possibility that serial correlation in case of using data jeopardize the efficiency of estimates many authors use various schemes of long-differences estimation (see Boarnet, 1998). Tables 9 and 10 present the results of estimating the three models. The general model of such an approach would be:

Model 1:

$$\begin{aligned} Y_{it} - Y_{i0} &= \alpha + \beta(K_{it} - K_{i0}) + \beta_1(KG_{it} - KG_{i0}) \\ &+ \beta_2(l_{it} - l_{i0}) + \beta_3(Un_{it} - Un_{i0}) + u_{it} - u_{i0} \end{aligned} \tag{18}$$

Model 2:

$$\begin{aligned} Y_{it} - Y_{i0} &= \alpha + \beta(K_{it} - K_{i0}) + \beta_1(KPG_{it} - KPG_{i0}) \\ &+ \beta_2(KSG_{it} - KSG_{i0}) + \beta_3(l_{it} - l_{i0}) + \\ &\beta_4(Un_{it} - Un_{i0}) + u_{it} - u_{i0} \end{aligned} \tag{19}$$

Model 3:

$$\begin{aligned} Y_{it} - Y_{i0} &= \alpha + \beta(K_{it} - K_{i0}) + \beta_1(KEG_{it} - KEG_{i0}) \\ &+ \beta_2(KFG_{it} - KFG_{i0}) + \beta_3(KIG_{it} - KIG_{i0}) \\ &+ \beta_4(KSG_{it} - KSG_{i0}) + \beta_5(l_{it} - l_{i0}) + \beta_6(Un_{it} - Un_{i0}) + u_{it} - u_{i0} \end{aligned} \tag{20}$$

where $u_{it} = \mu_i + \nu_{it}$.

In the first case long-differences are estimated by subtracting the year 2006 and year 1997 and running the OLS. Only public capital and physical capital (the F sector component) were estimated with a positive and significant coefficient in the long run period. Positive effects of construction investment on output growth probably come from constant positive short term effects on growth of wages and employment. It is less likely that the crowd-in effects of this category of capital caused such positive outcome on the aggregate level.

In the second case the dataset is prepared by subtracting the years between 2001 and 2006 from the initial year (1997). After that the obtained values were pooled. However, estimates do not give significant data (except for the labor and unemployment). It is possible that dynamics of the variables diverged through the time or the measurement error affected the estimates. There is a possibility also that in this case short-run and long-run estimate mix and in the case of different signs of coefficients give unreliable estimates.

Table 9: Estimation of the long-differences (case 1)

Dependent variable: ln (GDP)	**Number of observations: 21**		
Variables	**Model 1**	**Model 2**	**Model 3**
Constant	**-.2187182 (-0.16)**	**-.3703061 (-0.25)**	**.2710294 (0.16)**
K	**-.4738724 (-0.89)**	**-.3869461 (-0.68)**	**-.5759531 (-0.88)**
KG	**.5479519* (3.01)**		**.5405485 (0.85)**
KPG		**.3016189* (2.44)**	
KSG		**.296399 (0.53)**	
KEG			**.3973549 (1.55)**
KFG			**.055394*** (2.11)**
KIG			**.1092291 (0.30)**
L	**1.417071* (5.10)**	**1.462543* (5.04)**	**1.318196* (4.03)**
Un	**-.0076061 (-1.29)**	**-.0066301 (-1.05)**	**-.0080337 (-1.12)**
Adj R-square	**0.80**	**0.77**	**0.75**

Source: Author's calculation

t- values are in parentheses; *, ** and *** denote statistical significance at the 1%, 5% and 10% level

Table 10: Estimation of the long-differences (case 2)

Dependent variable: ln (GDP)	**Number of observations: 126**		
Variables	**Model 1**	**Model 2**	**Model 3**
Constant	**.1714413* (11.76)**	**.1746567* (11.69)**	
K	**-.0911077 (-1.80)**	**-.0807545 (-1.42)**	**-.0211409 (-0.38)**
KG	**.0215748 (1.24)**		
KPG		**-.0001609 (-0.01)**	
KSG		**.0366844 (0.62)**	**.0655073 (1.10)**
KEG			**-.0536421* (-3.83)**
KFG			**.0029721 (0.55)**
KIG			**.0108967 (0.75)**
L	**.9856202* (17.14)**	**1.012447* (16.14)**	**.9748848* (15.93)**
Un	**-.0043819* (-3.68)**	**-.0041408* (-3.31)**	**-.0045973* (-3.87)**
Adj R-square	**0.86**	**0.86**	**0.88**

Source: Author's calculation

t- values are in parentheses; *, ** and *** denote statistical significance at the 1%, 5% and 10% level

6.7. Instrumental variables estimation

One of the sources of potential bias and inefficient estimates are the simultaneous determination of capital, labor, and output. In the presence of such a correlation of the independent variable with the error term, conventional estimators will be biased and inconsistent (Holtz-Eakin (1994), Sturm, (1998), Kamps, (2004)). This presents the endogeneity problem. Holtz-Eakin, Newey and Rosen (1988) propose using first-differences to eliminate the state-specific effects and an instrumental variables estimator to circumvent the simultaneity bias (using first differences has the additional advantage of eliminating unit roots and common trends in the data). Holtz-Eakin (1994) uses first differencing to eliminate state effects and employs an instrumental variable to control for correlation between the independent variables and the error term. The use of this estimation procedure thus avoids inconsistency stemming from both the presence of correlated state effects and the simultaneous determination of inputs and output. In this case, regression is instrumented by first and second difference of the capital variables used in particular model, i.e. $x_{t-1} - x_{t-2}$ is used as an instrument for $x_t - x_{t-1}$. However, instrumental variables regression did not provide results different from the other differencing schemes already performed in the text before.

Table 11: IV - estimation

Dependent variable: ln (GDP)	**Number of observations: 147**		
Variables	**Model 1**	**Model 2**	**Model 3**
Constant	**.0386188* (7.26)**	**.0398014* (7.13)**	**.0395066* (5.43)**
K	**-.447122* (-3.55)**	**-.386687* (-2.96)**	**-.363371* (-2.77)**
KG	**.0193463 (0.54)**		
KPG		**.0180656 (0.71)**	
KSG		**-.2207474 (-1.49)**	**-.2180282 (-1.42)**
KEG			**-.0579711 (-0.87)**
KFG			**.0244803** (2.42)**
KIG			**.0021488 (0.04)**
L	**.7004617* (8.70)**	**.6899084* (8.62)**	**.6774209* (8.59)**
Un	**.0005886 (0.39)**	**.0004363 (0.29)**	**.0000677 (0.04)**
Adj R-square	**0.53**	**0.53**	**0.50**

Source: Author's calculation
t- values are in parentheses; *, ** and *** denote statistical significance at the 1%, 5% and 10% level

Estimated coefficient of labor and public capital variable in the F sector are positive and significant. However, it is hard to explain the high and significant negative values of the private capital stocks. There is a probability that labor-displacing features of private capital stocks had impact on the values of estimated coefficients.

6.8. Sectoral allocation of investments

The use of aggregate data does not reveal sufficiently strong linkages between public sector capital and private production activities. Therefore it is important to analyze the structure of government investments. The structure of net stocks of the Croatian economy is presented in table 12. It can be observed that this structure changed over the years and that some sectors have positive and other negative dynamics. It can be seen that public capital and especially the F sector had positive trends and, surprisingly, it seems that those of the largely private D sector were reduced. This could be one of the consequences for the negative elasticity of output on change in the private capital. It is possible that the regression captured the dynamics of investment reduction and that these estimates do not address the effects on productivity.

Table 12: Structure of net capital stocks of Croatian economy in period 1996-2006 (in percentage)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
A	2,38	2,49	2,54	2,56	2,66	2,70	2,69	2,63	2,58	2,58
B	0,12	0,13	0,12	0,11	0,11	0,12	0,12	0,11	0,11	0,10
C	0,50	0,53	0,61	0,61	0,64	0,66	0,70	0,77	0,77	0,79
D	23,03	22,40	21,67	20,87	20,28	19,72	19,09	18,32	17,55	16,82
E	11,47	11,53	11,39	11,27	11,20	11,03	10,88	10,68	10,53	10,46
F	1,60	2,02	2,52	3,15	3,58	4,23	5,12	6,43	7,54	8,40
G	4,10	4,28	4,52	4,78	5,11	5,61	6,12	6,68	7,10	7,51
H	5,35	5,35	5,45	5,45	5,34	5,22	5,26	5,29	5,32	5,31
I	11,56	11,71	11,87	12,12	12,32	12,22	11,95	11,67	11,53	11,40
J	1,40	1,51	1,56	1,73	1,88	2,17	2,52	2,86	3,20	3,44
K	21,88	21,65	21,48	21,12	20,84	20,49	20,04	19,47	19,00	18,62
L	8,09	7,91	7,86	7,73	7,55	7,28	6,97	6,60	6,26	5,99
M	3,34	3,23	3,14	3,10	3,08	3,07	3,05	2,98	2,92	2,86
N	3,35	3,27	3,16	3,08	3,02	2,95	2,88	2,79	2,70	2,65
O	1,81	1,99	2,11	2,31	2,41	2,52	2,60	2,72	2,88	3,06
TOTAL	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

Source: Author's calculation

6.9. Aggregate investment spillovers in Croatian counties

Finally, by using cross-section data on counties it is possible to determine the spill-over effects of investments. Results are presented in table 13. Models used for their estimation are:

Model 1:

$$Y_{it} = \alpha + \beta K_{it} + \beta_1 KG_{it} + \gamma sKG_{it} + \beta_2 l_{it} + \beta_3 Un_{it} + u_{it} \quad (21)$$

Model 2:

$$Y_{it} = \alpha + \beta K_{it} + \beta_1 KPG_{it} + \beta_2 KSG_{it} + \gamma_1 sKPG_{it} + \beta_3 l_{it} + \beta_4 Un_{it} + u_{it} \quad (22)$$

Model 3:

$$Y_{it} = \alpha + \beta K_{it} + \beta_1 KEG_{it} + \beta_2 KFG_{it} + \beta_3 KIG_{it} + \gamma_1 sKEG_{it} + \gamma_2 sKIG_{it} + \gamma sKEG_{it} + \beta_4 KSG_{it} + \beta_5 l_{it} + \beta_6 Un_{it} + u_{it} \quad (23)$$

Where $u_{it} = \mu_i + \nu_{it}$ and the prefix γs_{it} denotes neighboring counties' capital matrix used to calculate possible neighboring county net capital stocks effects on the economic growth of the particular county. The results indicate the presence of high spill-over effects of the physical part of the public investment (and especially within the F sector). In addition, according to estimates, neighbor county capital has higher elasticity than the capital installed within a particular county.

One of the logical reasons for high level of spillovers is in inequality of economic development and income distribution among Croatian regions. For example, employment and wages of neighboring counties to Croatian capital city, Zagreb, strongly depend on investment activity of that city. This is easiest to see by data on employment and wages of Zagrebačka County. This county has highest average wage in Croatia. One of the most visible effects of investments is in form of unemployment reduction in county where investment activity occurred but in neighboring countries also. Besides that there are certain negative spillover effects. This is mainly related to the fact that when certain larger scale investment activity is undertaken in Croatia, majority of work is done by companies located in Zagreb. However, such negative spillovers cannot be seen in the estimation due to fact that only neighboring capital was included in estimation. The same situation occurs, but in lesser extent, in case of other larger cities in Croatia. Clearly positive effects of neighboring capital stocks increase can be seen on example of counties around Ličko-Senjska County. This is related with highway investments in period 2001-2004.

Spillovers from the highway investments are especially interesting to analyze. Boarnet (1996) in his research examines spillover effects of street-and-highway capital, using data for California counties in period 1969-1988. He distinguishes negative spillovers that come from the fact that infrastructure-rich locations gain output at the expense of the places from which factors of production migrated. These negative effects could offset benefits from capital invested in roads. He argues that highway capital has features of "point infrastructure" with strictly local benefits and "network infrastructure" as spillover benefits in form of facilitating travel between different regions. However, in case of highway investments spillovers in Croatia it is obvious that these benefits are of short run nature. The result of between estimation suggests that it is probably still early to capture long-term effects and it is not certain whether these effects will be substantial due to fact that highway traffic that goes through these counties is still far from congested. It is also not likely to expect point infrastructure benefits due to fact that highways do not pass through heavily populated area. However, only certain and visible long-term effect is in fact that price of land surrounding highways has risen dramatically. Whether satisfactory level of network activity will occur is still early to see because these roads are in use only for two years till now.

Table 13: Spillover effects of the public investments in Croatia

Dependent variable: ln (GDP)				Number of observations: 210								
Variables	**Pooled OLS**			**Within**			**Between**			**Random GLS**		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	-2.33019* (-21.01)	-2.31193* (-24.08)	-2.09497* (-23.35)	-4.85813* (-6.02)	-3.32831* (-3.13)	-.8720189 (-0.91)	-2.16954* (-8.65)	-2.16652* (-10.75)	-1.87082 (-8.13)	-2.91758* (-12.30)	-2.69268* (-14.29)	-2.31697* (-12.36)
K	.0411393* (2.66)	.060575* (4.01)	.0448337* (2.99)	.0177858 (0.25)	.027751 (0.37)	-.0813502 (-1.18)	.049386 (1.38)	.0658853* (2.09)	.0684057 (1.80)	.0665384** (2.26)	.0674673** (2.27)	.023302 (0.78)
KG	.0950236* (8.37)			.051374* (2.61)			.0697192** (2.39)			.1041698* (6.57)		
KPG		.0817976* (11.44)			.0432481* (3.18)			.0726186* (4.06)			.0739565* (7.65)	
KSG		-.051966* (-3.17)	-.0308486** (-2.02)		-.0675481 (-0.83)	-.0143586 (-0.21)		-.0579505 (-1.65)	-.0479979 (-1.25)		-.0297847 (-0.99)	.0080986 (0.28)
KEG			.0292946* (3.06)			-.0562643** (-2.52)			.027611 (1.13)			-.0090962 (-0.55)
KFG			.0134286* (3.11)			.0158648* (2.62)			-.0016604 (-0.10)			.0128114* (2.70)
KIG			.040368* (5.69)			.1004556* (4.30)			.051714** (2.73)			.0587307* (4.59)
L	.9191742* (63.75)	.9585215* (66.62)	.9452787* (62.53)	1.075778* (13.24)	1.036813* (12.52)	.9421591* (13.12)	.9308271* (28.90)	.9632164* (32.48)	.9296178* (24.61)	.9020973* (28.82)	.950216* (33.03)	.9612768* (32.80)
Un	.0010913** (1.99)	.0007539 (1.53)	.0001642 (0.37)	.0049491* (4.02)	.0034918* (2.74)	.0010799 (0.88)	.0003085 (0.23)	-.0000612 (-0.05)	-.0006185 (-0.51)	.002311* (2.83)	.0019398* (2.65)	.0009564 (1.39)
Dummy	-.060588* (-4.51)	-.054669* (-4.56)	-.045559* (-4.38)	-.041728* (-4.56)	-.042678* (-4.67)	-.041387* (-5.38)				-.049346* (-4.90)	-.048137* (-4.90)	-.042327* (-5.22)
sKG	.01215** (2.25)			.1521126* (5.15)			-.0008463 (-0.07)			.0552457* (5.21)		
sKPG		.0077833*** (1.75)			.0989867* (5.03)			-.0038389 (-0.39)			.0364367* (4.73)	
sKEG			.0008747 (0.08)			-.0214865 (-0.67)			.0166746 (0.55)			-.0190034 (-1.05)
sKFG			.0260466* (4.90)			.0635297* (7.94)			-.0180753 (-0.73)			.0397248* (6.89)
sKIG			-.015103 (-1.56)			-.0300645 (-0.78)			-.0033375 (-0.13)			.0015946 (0.09)
R-square	0.99	0.99		0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
LM-test										104.85*	59.02*	95.01*
Hausman test										5.18	101.63*	29.71*

Source: Author's calculation

t- values are in parentheses; *, ** and *** denote statistical significance at the 1%, 5% and 10% level

6.10. Discussion

The methodology of estimation by using the cross-section time-series regression approach is derived from several studies – Baltagi and Pinnoi (1995), Boarnet (1996), Sturm (1998), Ligthart (2000), Kamps (2004). The reason for using several models and estimation techniques, the usual panel regression procedure, then controlling for spillover effects and using the long-differences and instrumental variables estimation – is to try to show the robustness of the results. The robust results are shown in the case of physical capital and especially in the construction (F) sector. However, in explaining the estimation results, several notions regarding the data and methodology have to be pointed out.

The main reason for the derivation of regional data on GDP and capital stocks was to try to capture as long time period as possible. Reasonable data could be provided only from the year 1997. Several obstacles prevented using data prior to 1997. This is mainly due to high inflation, unreliable and non-existent statistics, changes in territorial and administrative organization of government units, and changes in statistical methodology. However, after the estimation, the results show that, in a 10 year period, it is still hard to capture the long term effects of investments. This may be due to several reasons. The first possibility is that some sort of measurement error makes estimation unreliable. Second is the logical fact that a short time period is not sufficient to show long-term effects and probably it is not possible to distinguish short-term and long-term effects. In addition, perhaps the physical component of public capital did not produce substantial long-term effects which would mean that investments were not efficient. However, estimation shows a robust coefficient on the short-term effects of construction sector as part of the public capital stock. If we consider that in the light of the Baxter and King (1993) thesis of the positive effects of a permanent increase of public investment on output growth – isn't that the case that high investment/GDP ratio in Croatia brought long-term output-growth, or at least growth in the medium term. Finally, it must be mentioned that public investments in Croatia increased significantly from the year of 2001 and it is indicative that from this year Croatia has had much higher and more stable growth rates of the economy. It should also be noted that many other institutions and governance in Croatia improved since 1997 – in terms of the cost of capital, rule of law, and reform of government institutions.

Regarding the derivation of GDP and capital stocks which was clearly important for our estimation several points appear to be important. GDP was derived by using proxies of the combination of the average wage and employment. That approach brought a certain bias in the estimation, although, as it is shown in the appendix, these derived data match official data for the period 2001-2004 quite well. One of the problems is that the growth of productivity of the Croatian economy does not match perfectly the growth of real wages. Part of the productivity growth was retained as profits that were reinvested in companies or transferred out of the country (due to the fact that during the privatization process many public enterprises was sold to foreign companies). These enterprises were all in profitable sectors – financial services, food industry, and communications. After privatization some of these companies tried to increase profits via cost reduction, i.e. reducing their employment. Wages in these enterprises were also kept at a low level. Because of that there is a bias in the estimated coefficient of labor variable i.e. estimates show higher elasticity of output on the increase of a unit of labor. However, part of the public investments, such as construction of highways and other facilities were labor intensive.

The PIM methodology used for the derivation of capital stocks is also biased. Capital stocks present the basis for the productive services of the economy. Investments on the other hand are a flow variable which influences the short-run rise in wages and employment. However, within the regression equation when using the capital stocks – both effects are mixed and it is hard to distinguish direct and lagged effect incorporated within the capital stock variable. It is shown that short-run and long-run effects can have quite opposite dynamics. From that point there can be several situations based on such dynamics: both effects could be positive, one could cause reduction and other decrease of output growth, both could be negative (disinvestment situation). Such a theoretical possibility is presented in the case of the county of Ličko-Senjska where from the year 2001 substantial positive short-run effects occurred which were caused by an increase of public investment in the construction sector. However, after the year 2004 when this period of increase of investments ended, output, wages, and employment level did not drop back to the original level but were reduced only by a small percentage. Obviously, after several years long-term effects kept the regional economy in a much better position than from the starting point.

Looking at the estimation of the model is important to address several issues. It appears that the estimated coefficients are much lower than in numerous other studies. This certainly seems reasonable especially in light of the fact that Ashauer's implausibly high coefficients were found to be spurious due to the improper econometric procedure applied. However, somewhat higher coefficients on public capital should be expected. It would be logical that public investments in Croatia as a country still in a developing stage would have higher rates of return on the public investments' increase. However, estimation results do not show this. On the contrary, coefficients appear to be rather low. That could occur for several reasons. First, it is likely that the already mentioned bias in the derivation of the GDP underestimates the contribution of capital to GDP. As a confirmation of this, it can be seen that coefficients of the labor variable are larger than 1 (i.e. more than 1% increase in output for a 1% increase in labor) i.e., the labor factor is overestimated. Second, there are two periods that present different investment patterns. Until the year of 2001 there was a much lower level of investment activity and until the year 2002 unemployment rates were high (and even increasing). After that year there was a increase of investments and employment as well (see data on gross capital formation and employment in the appendix). That could be a reason for lower coefficients because the regression averages the coefficient for the whole period. Third, the institutional setup of the investment process was much more favorable from 2001 and it can be expected that rates of return were higher at that period. In addition, the cost of capital was much lower. Finally, it is shown that there is a certain measurement error in terms of mixing the long-run and short-run effects when using the capital stock variable. Therefore, short-term effects of investments are much higher than the estimated coefficients show.

The comparison of the estimation results made by estimating the regression coefficients of two datasets, one with the author's GDP estimates and the other with official data on regional GDP in the period from 2001 to 2004 provides some answers (tables 6 and 7). Considering the sign and significance of the coefficients there are some important differences. However, the values of the coefficients are higher in the case of estimation of both datasets for the period 2001-2004 than these from the estimation in table 4. It was already mentioned that this is logical because investments were much higher in that period and the institutional background was much more favorable. However, there are important differences between estimation based on my data and the official dataset. As expected, coefficients on both private and public capital are much higher in the case where official data are used (table 7). This is definitely a proof that capital stocks' contribution to the output growth, with estimation based

on the whole (table 4) is underestimated. In addition, is seems that private capital coefficients are much higher using the official data. It is possible that public investments were more oriented to increasing employment and private sector investments to an increase of wages. In addition, reforms within the public sector did not go toward a reduction of government employment while public works in the construction sector brought a significant rise of employment in certain counties. On the other hand, within the sectors of a national classification of industries defined as private, employment oscillated in the period between the year 2001 and 2004. That is the reason why the coefficients on labor in the table 6 are much lower and in table 7 are not significant. On the other hand sector F has a substantial increase of employment and that partially causes the differences in coefficients because the author's data are more biased in favor of the labor factor. Summary of the short run effects on output growth presented by coefficient values of various forms of capital are presented in table 14 below.

Table 14: Summary of the estimated coefficient values

	table 9, within estimation	table 11, within estimation	table 12, within estimation
K	**0,160**	-0,011	**1,027**
KG	**0,057**	**0,180**	**0,378**
KPG	**0,390**	**0,136**	**0,270**
KSG	0,080	0,058	**1,080**
KEG	-0,030	0,049	-0,010
KFG	**0,028**	**0,069**	**0,137**
KIG	**0,070**	-0,016	0,090

Source: Authors calculation, coefficients derived from the tables 9, 11 and 12, bolded values are significant at 10% level

In addition, it can be seen that for the components of public capital in general, physical capital and capital in the construction sector there are consistent and positive coefficients. However, it can be noted that disaggregating capital reduces the coefficients on particular types of capital and remaining aggregate private capital as well. Munnel (1990) gave an explanation that by aggregation of regional data more and more spillover effects are captured in aggregate data. Although some authors reject such a conclusion (Holtz-Eakin, 1994), in the case of Croatian counties that is a plausible cause of the coefficient change. It can be expected that spillovers would be higher in the case of smaller regions.

However, results of the estimation of the effects of public capital differ greatly from a similar study conducted by Baltagi and Pinnoi (1995). Although in both studies within estimation is accepted as being more efficient, there is a difference in the estimation results. They found total public capital stock to be insignificant but separating into components reveals that water and sewer sector provides positive effects for private productivity. Surprisingly, they find highways to have insignificant effects and other public sector construction to have negative impact on aggregate output. They explain negative effects by the excess capacity of that kind of capital. However, they admit that such a variable is not the best indicator of education and health services. There could be several reasons for the difference of the estimates – different datasets, methodology in collection of the data, that they use the period from 1970-1986, the issue of investment needs of particular economy, or the institutional setup. However, the high coefficients of the labor factor are similar. If we relate increase of employment due to additional investments that could be one of the important channels of output growth. Of course, that is true under the premise that the private sector cannot stimulate additional

employment in certain periods. This is especially true for Croatia with a situation of high unemployment rates and a developing market economy.

Recent research suggests that important effects on the estimation results, when using the cross-section data, can be presented in the form of spillovers. The geographical shape of Croatia suggests that it is sensible to use only capital from a neighboring county to estimate spillover effects. It is highly unlikely that distant regions of Croatia show spillover effects. This could be the case only for the metropolitan regions – there are four large cities that have effects on a larger area. However, that could be a problem for future research.

Different models are used in order to ascertain the robustness of the results. There are three aspects considered in the model – short run effects, long-run effects, and spillover effects. Physical capital and its component sector of construction showed positive and significant effects in almost all cases. However, these positive effects relate to the direct short-run impact. It seems that measurement error is much more significant in the long-term effect considerations. However, although the long-term values of coefficients of the capital factor appear to be ambiguous, it can be seen that long-term effects of investments are in the form of an increase of the labor factor (see between regressions in table 4). Due to the fact that Croatian counties are small areas in terms of population and size significant spillover effects can be expected. Estimation results confirm that thesis and the positive impact of installing the capital in neighboring counties seems to be even higher than the investments in its own regions.

7. Conclusion

By the utilization of panel regression techniques, both ones that rely more on static analysis and others that are oriented to dynamics, a positive contribution of the capital accumulation to economic growth was determined. These findings are especially significant and robust in the case of government investments of physical capital. Within that group government investments in large scale construction works and infrastructure resulted in high short-term increases of regional output (and national in the smaller scale). However, it is hard to give a definitive answer on the long-term effects due to the short time period analyzed. In addition, estimation showed the existence of high positive spillover effects of the investments of neighboring regions on the particular region growth of income, employment and GDP.

There are numerous limitations to this research which stem from several sources. Research of the effects of capital accumulation was difficult due to the fact that official datasets on the time-series of regional GDP and net-capital stocks still do not exist. Therefore, the data had to be derived and during that process certain bias and measurement errors occurred. Due to the overestimation of the contribution of labor, aggregate capital stock and different parts of capital stocks are underestimated. In addition, net capital stocks data derived by utilizing the PIM method are also cause of potential bias. These stocks provide the basis for the productive services in the economy and therefore show long-term effects on growth of the economy. However, use of capital stock variable reduces the short-term effects of investment in terms of increased wages and employment. Therefore, the estimated coefficient of capital stock variable in the short time period presents a certain mixture of the medium and short term effects. In addition, even theoretically, it is hard to believe in the precision of estimation when many heterogeneous items are aggregated. For example, capital goods built in various time periods, with different costs and different productivities.

There are limitations regarding the methodology used for the estimation of the public capital effects on economic growth. The panel data regression technique provides only average coefficients over the whole national space. It does not allow specific differences of particular regions that might lead to a different impact of public investments on a particular region. However, this is the most suitable method for estimating this phenomenon by the available dataset. There are many limitations on the utilization of the Cobb-Douglas function as well. This function cannot distinguish shifts in the function (technical progress) from movements along the function (changes in factor intensity) unless the assumption of neutral technical progress is made.

Measurement issues related to the dataset also made the results of the estimation much less clear. That is especially the case when the long-term impact of public investments is examined. In that process the changes in the short-term and long-term impact change the results of the estimation. Due to fact that it is not possible to distinguish these effects the results remain unclear. This is one of the main reasons why the results of dynamic panel regression techniques could be unreliable (in addition to the small time series).

An additional limitation of this research is that the focus was on the estimation of the public capital exclusively in terms of physical capital. Not much attention was devoted to the role of human capital. However, there are also obstacles to measurement of the human capital in terms of the available statistics.

In addition, there are special possibilities in determining the institutional setup of the investment process, especially the effects of financial market development and financial regulations on the costs of financing investments. The further research agenda follows largely from certain shortcomings of this research. There are several important tracks of the research orientation.

Development of the database of the government institutions will provide additional datasets for more reliable estimates and reveal the long-term relationships among the national economic indicators. Our research provides a base for such developments. A longer time period could provide an opportunity for testing various econometric approaches such as VAR, nonlinear regression, or spatial econometric techniques. In terms of panel regressions it would be useful to give more emphasis on the dynamic effects of the capital accumulation by utilization of various dynamic panel regression models. The reason for the utilization of these techniques is that each of these approaches has its different assumptions. Because of that it is important to test which method is more appropriate and which particular method gives answers regarding different channels of impact of capital accumulation on the economic growth process.

Voluminous empirical literature gives witness to the complexity of channels of investment impact on economic development. Further research should be oriented to determining the forces of institutional design of an economy that would enable optimal results in terms of efficiency. There are numerous areas of research providing interest in developing the final "verdict" on the public capital effects. These issues are related to the process of financing of public investments, planning processes, setup of the government sector, influence of the bureaucracy, and corruption.

The conditions of the Croatian economy demand high investment levels. The economy is in a state of low-level equilibrium growth and needs proactive investment policy. At the same time government has to reduce its administrative burden on the economy. For the successful realization of high rates of economic growth large scale coordination of government activities is necessary – additional investments have to be supported by appropriate institutional surroundings.

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