# Spillover effects of public investments in Croatia

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## Abstract

*The paper deals with spillover effects of public investments in Croatia. The hypothesis of high positive spillover effects of public investments in Croatian regions is confirmed. Particularly high coeffients are estimated on spillovers from the highway investments. However, in case of highway investments spillovers in Croatia it is obvious that these benefits are of short run nature. Reliable dataset suggests that it is probably still early to capture long-term effects. The results of the research indicate that public investments are usefull tool for regional growth convergence espeacially by increasing the wages and employment in short term and potentially crowding in private investments in long-term.*

**Key words:** spillover effects, investments, highway infrastructure, Croatia, regions

**JEL Classification:** C33, E01, E22, H54

## 1. Introduction

The evolution of empirical contributions on the issue of effects of capital accumulation on economic growth begins with the papers of Abramowitz (1956) and Solow (1957). These seminal papers introduced the empirical methodolofy that enabled to distinguish contributions of individual factors of production to the economic growth. 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 such as Netherlands and Spain.

Development of multivariate time-series such as 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, Mittnik and Neumann 2001, and Voss 2002, Kamps, 2004). Economic models that incorporate spatial effects are becoming increasingly popular Anselin (1988, p. 8). 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, 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).

It is important to adress the issue that research on regional level shows much more controversity. Munnel (1990) was the first author that obtained quite different results of estimation when using datasets on national and regional level. Numerous explainations for that phenomenon are provided afterwards but such difference still remains unexplained. One of the logical reasons is found in spillover effects (see Holtz-Eakin 1994, Garcia-Mila et al., 1996, Boarnet, 1998). Authors research impact of both positive and negative spillover effects of neighbouring region investments on regions output that makes aggregate and regional estimation results to differ. In addition, research in this area is mainly focused on transportation sector.

In spite of the fact that research on capital accumulation effects on growth is voluminous the problem remains that only few countries are included in research. There is still no research on capital-growth puzzle in transition economies and particularly spillover effects of investments in regional context. One of the reasons is in lack of data and unstable macroeconomic conditions that makes such research difficult and less significant. Therefore, this research presents attempt to overcome the gap in the literature.

The paper deals with spillover effects of public investments in Croatia. The hypothesis of high positive spillover effects of public investments in Croatian regions is tested. One of the logical reasons for high level of spillovers is in inequality of economic development and income

distribution among Croatian regions. One of the most visible effects of investments is in form of unemployment reduction not just in county where investment activity occurred but in neighbouring counties also. Spillovers from the highway investments are especially interesting to analyze. Croatia had substantial investment in highway infrastructure in recent years. However, in case of highway investments spillovers in Croatia it is obvious that these benefits are of short run nature. Reliable dataset suggests that it is probably still early to capture long-term effects and it is not certain whether this 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 observe because these roads are in fuction for short period.

In the first part of the paper, after introduction, a survey on empirical literature on spillover effects of investment is conducted. After that the methodology for deriving the capital stocks and GDP per Croatian regions is described. Empirical estimation of spillover effects in Croatia is conducted by cross-section time-series regression techniques. Conclusion draws some recommendations for practical policy, limitations and guidelines for further research.

## 2. Dataset and methodology

### 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.

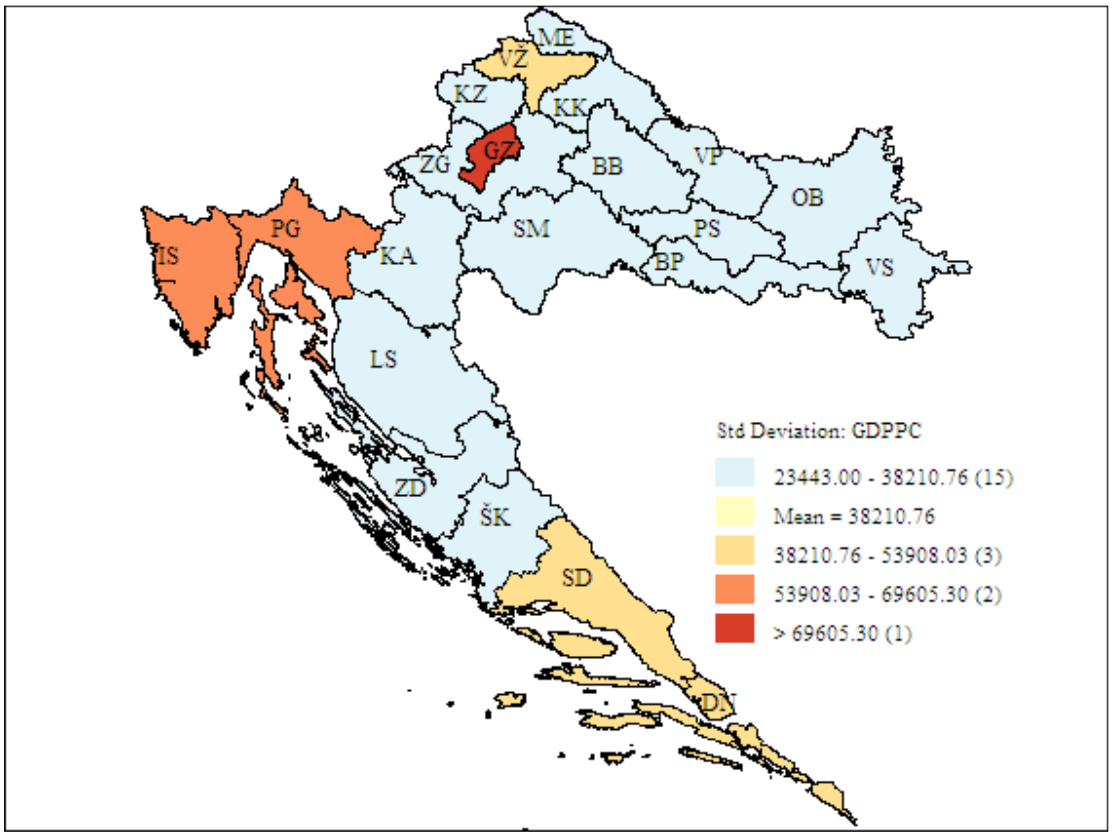


**Figure 1: GDP per capita in Croatian counties in year 2006 - standard deviation from the mean**

Source: Author's calculation

Table 1 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.

An important question arises. 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.

Data from table 1 show 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 2 shows different growth dynamics in Croatian regions.

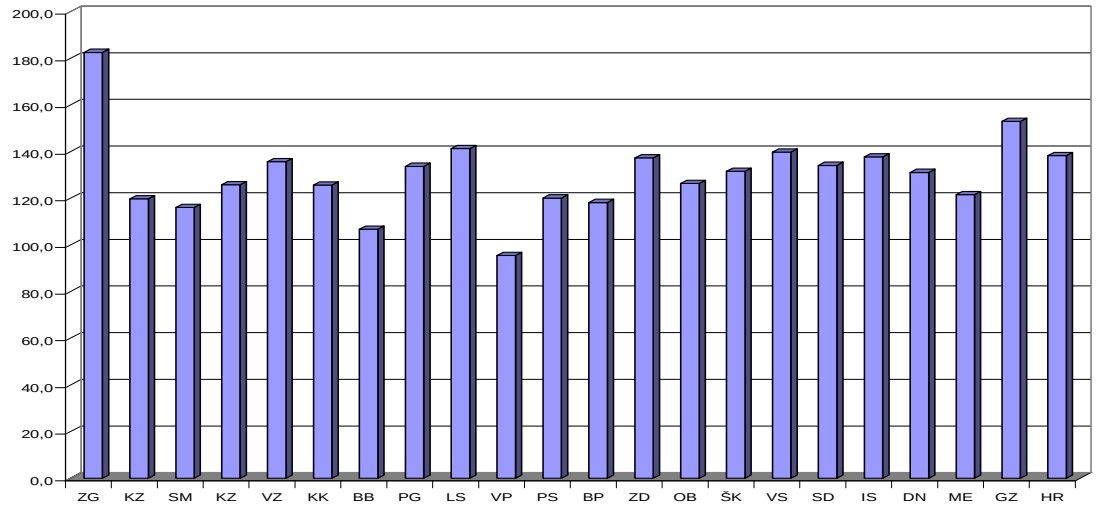


**Figure 2: GDP per capita, by counties in 2006 (1997=100)**
*Source: Author's calculation*

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).

**Table 1: 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)*

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 table 1 shows, 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 3), 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?

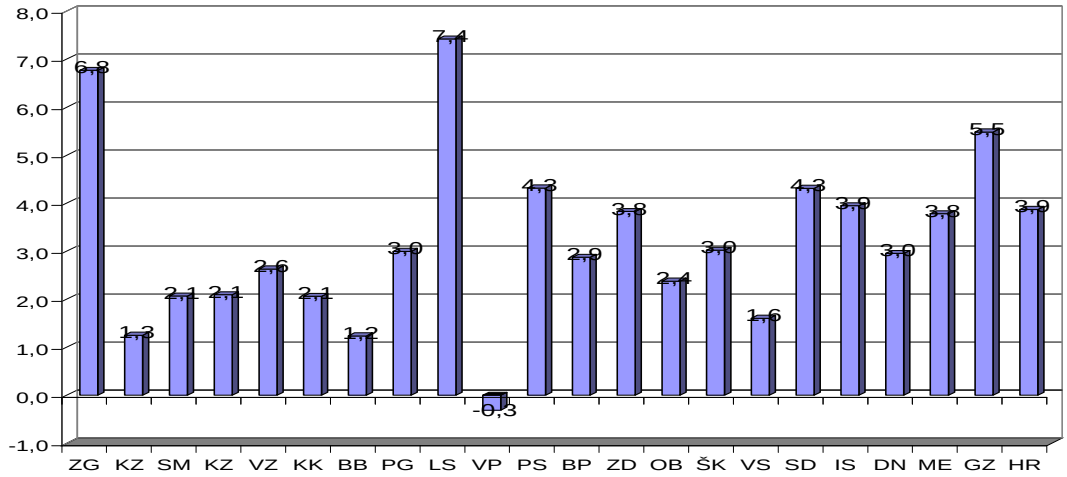


**Figure 3: Average real GDP growth rates in the period 1997 – 2006 (in percent)**
*Source: Author's calculation*

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).

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.

## Dataset and methodology

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.

## 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 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.

## 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[1]:

- 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 2. 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.

**Table 2: 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 |

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

| | |
|---|---|
| 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).[2] 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[3]).

- private investments in services,

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

- 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.

[2] 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.

[3] Entered into the process of privatization in 2005

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 5.

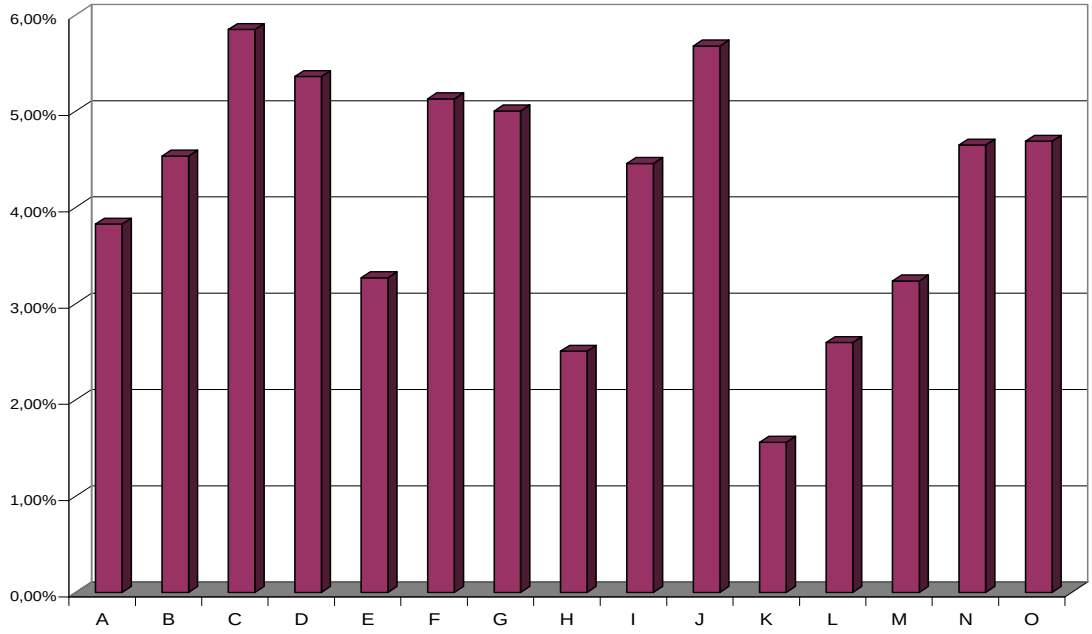


**Figure 5: Depreciation rates across the Croatian economy sectors (in percent)**
*Source: Author's calculation*

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.

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.

## 3. Model estimation and discussion

Finally, by using cross-section data on counties it is possible to determine the spill-over effects of investments. Results are presented in table 2. Models used for their estimation are:

**Model 1:**

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

**Model 2:**

$$Y_{it} = \alpha + \beta K_{it} + \beta_1 KPG_{it} + \beta_2 KSG_{it} + \gamma_1 sKPG_{it} + \beta_3 l_{it} + \beta_4 Un_{it} + u_{it} \quad (7)$$

**Model 3:**

$$\begin{aligned} Y_{it} = {} & \alpha + \beta K_{it} + \beta_1 KEG_{it} + \beta_2 KFG_{it} + \beta_3 KIG_{it} + \gamma_1 sKEG_{it} \\ & + \gamma_2 sKIG_{it} + \gamma_3 sKEG_{it} + \beta_4 KSG_{it} + \beta_5 l_{it} + \beta_6 Un_{it} + u_{it} \end{aligned} \quad (8)$$

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.

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.

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 $\gamma_{it}$ which stands for the state-specific effects and term $\upsilon_{it}$ for random disturbance. Depending on the treatment of the $\gamma_{it}$ 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.

Prefix $\gamma s_{it}$ denotes coefficient on neighboring counties' capital matrix used to calculate possible neighboring county net capital stocks effects on the economic growth of the particular county (approach similar as in Boarnet, 1998, p. 388). 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.

Pooled OLS, fixed (within), between and random estimations of the models are performed. The important issue is which of the estimators is most efficient. For that reason 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 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 therefore, the fixed (within) effects estimator is considered to be consistent unlike the random estimator. However, both of the tests gave similar results.

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 three years till now.

**Table 2: 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*

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. 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, 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.

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.

## 4. Conclusion

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. 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. 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.

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 regional GDP and net-capital stocks still do not exist. Therefore, the data had to be derived and during that process certain biases 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.

The results of the research indicate positive effects of public investments on economic growth. Furthermore, estmation results show high level of spillover effects. Such results can be used as a indicator when analysing tools for attaining regional economic convergence. Public investments directed towards particular region will rise output not just in that region but in sorrounding regions as well. In case of low level of resourse utilization, as is the case in Croatian regions, public investments are successeful instrument of economic development.

Further research will be oriented towards providing more accurate coefficients of estimation by devoting more attention to the weighting matrix used for estimating spillover effects. The colnclusions of this aggregate analysis can also be supported by anylsis of sector specific contributions of production factors by using the value added by sectors. However, this approach will be possible by development of appropriate database.

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