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Challenges in analyzing correlation between water infrastructure and economic development

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Abstract

Availability of infrastructure significantly influences the development of regions and countries, hence theoretical and empirical research on the relationship between infrastructure capital and economic growth should provide answers to an important question: increasing the stock of public capital can stimulate economic growth? The issue of investment in infrastructure is critical as infrastructure development in Romania is supported by the EU Structural and Cohesion Funds. Channels and models of economic growth with one factorial variable characterizing the infrastructure will be compared, analysing their approaches, features and limits.

Also, our case study will present some results for the impact of selected categories of public infrastructure sectors on the recent economic growth performances in some EU new member states. Thus, we hope to identify and discuss some conceptual and methodological challenges of grounding policies of development for various types of infrastructure. For Romania, we estimate the correlation between water supply and sewerage infrastructure and economic development indicator GDP per capita, at the regional county level.

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1. Introduction

This paper was based on some recent study and research outcomes dedicated to the post doctoral thesis „*Investments in Environmental Infrastructure: Obligations and Opportunities for Romania's Sustainable Economic Development*” (Frone Simona, 2012). Romania's ability to provide efficient infrastructure and environmental services, both nationally and locally, is an important factor in stimulating and supporting sustainable economic development and the focus of our thesis is on the Water Supply and Sanitation (WSS) infrastructure, as the main part of the environmental infrastructure and a sensitive development issue for Romania.

One of the main research goals of the postdoctoral paper was the theoretical, methodological and empirical analysis of the correlation between investments in water infrastructure and economic development. The section named *Mathematical models of economic growth with a factorial variable characterizing the infrastructure* was dedicated to the study, comparison, analysis and applicability of important mathematical economic models of growth with an explanatory capital infrastructure variable. The infrastructure concept is explained, with the main channels through which this modern category of mainly public capital may influence economic growth and development; it also summarizes the most important types of mathematical and economic functions and approaches used to measure the impact of investment or resources of public infrastructure capital on economic growth.

In the following section: *Limitations and challenges for conceptual and methodological analysis of the correlation between WSS infrastructure and economic development at local, regional, national level* actually we proceeded to the application of linearized model of production function to analyze this correlation, showing first the main obstacles and conceptual and methodological limitations of this approach, both in general and especially for Romania, atypical in Europe in terms of the gap (shortfall) of endowment and access to public utilities networks for water supply and sanitation. Empirical applications are then presented to measure the impacts of infrastructure capital by estimating the elasticity of output (GDP) on the input of water infrastructure, identified by some proxy variables for which there were available data sets; there are several own regression computations and analysis of specific issues and challenges concerning the correlation between access to water infrastructure and socio-economic development at national and regional level.

2. Conceptual and theoretical issues

As analysed and argued in the doctoral paper (Simona Popescu Frone, 2000), an important class of capital for economic growth is the public capital, objectively requiring state action and investments. Public capital consists, in countries with market economies, especially in public infrastructure. This includes roads, highways, ports, dams, bridges, airports, water supply networks and sanitation, environmental protection systems, hospitals and some productive forms of capital typically publicly provided.

Recent realities of the market economy, namely the global economic and financial recession really show that not always all private savings automatically and effectively turn into a sufficient volume of investment, especially in an appropriate investments structure that would stimulate and support sustainable economic growth and socio-economic development. Likewise human capital, public infrastructure can be incorporated in the production function to explain the residual growth factor; it is a public good financed by public saving, not usually traded on international markets so that in some countries (including Romania) accumulation of public infrastructure may be insufficient, hence delaying economic growth convergence with other states.

Public capital, especially the infrastructure capital is essential for economic and social activities carried out by the population in households and businesses. Nevertheless, empirical research on the relationship between public capital and economic growth should provide answers to some important questions: first, by increasing the stock of public capital we can stimulate economic growth? Another issue relevant to economic policy is the net economic growth effect of these investments in infrastructure, which might this way divert resources from other uses (Canning D. and Pedroni, P. 1999).

However, public investment related to development of infrastructure and provision of public goods can be complementary and not competing private investment. Public investments of this nature enhance opportunities for private capital and increase the productivity as well as the demand for private sector production and related ancillary services through the expansion of aggregate economic activity and saving. Therefore, one can state that the marginal

productivity of capital (investment) of the private sector reflects also the rate of public sector infrastructure investment.

From a conceptual perspective, infrastructure is generally defined as a composite of capital goods which are not consumed directly, as they offer service only in conjunction with labor and other inputs. This description allows to distinguish a range of components to examine their direct impact on development issues and highlights the need to specify the sector of infrastructure, in order to measure its impact on economic and social development.

The impact of infrastructure investments on the country's development is an important issue for government policy and strategic development of the country, especially during periods of recession or economic transition. Therefore, there is a quite recent trend of revival and resuming of Keynesian economic paradigm in the attempt to find a resolution to the global economic and financial crisis (Yifu Lin J., Doemeland D., 2012).

There are numerous and significant studies in the literature that addresses the issue of the role of infrastructure capital in economic development. These studies suggest several definitions for the infrastructure sector and its components while the authors analyze and interpret broadly characteristics and functions of infrastructure capital. The issues, factors and the effects of growth actually modeled and measured empirically are mainly based on data available for different countries and regions, as we show in what follows.

In the market mechanism of economic development, the infrastructure capital has several valences. Thus, in terms of stimulating the supply, there is both a direct channel (where the infrastructure capital stock serves as an input) and an indirect (through the modernization and expansion of infrastructure driving technological progress).

From another perspective, that of demand, the infrastructure provides the services people need and want: water and sanitation services; energy supply for heating, cooking, and light; access to telephone and computer; transport services. The absence of some of the most basic infrastructure services (in particular, water and sanitation or electricity) is an important dimension of the concept of poverty. Therefore the development of the infrastructure stock has a direct impact on reducing poverty and increasing national wealth.

Most of the channels considered in the context of growth theory support a link between the infrastructure stocks (or their variation) and economic growth. Of course, in the case of direct productivity channel, they find impact of an increase in the amount of infrastructure capital on the total factor productivity. Also, through potential indirect channels involved in theory, economic growth is based on the impact of more developed infrastructure on the productivity of other factors. Thus, there will be private capital costs adjustment, some cases of economies of scale and scope, as well as human development and labor productivity increase.

Based on these mechanisms and by applying theories of economic growth, numerous studies and research attempt to analyze and estimate the correlation between infrastructure development and economic growth. Some modern authors of studies in this area (Agenor and Moreno- Dodson, 2006; Fourie , 2006) argue that the impact of infrastructure on economic growth occurs in principle in several ways:

- Infrastructure reduces the cost of input factors in the production process. This is called a direct productivity effect;
- The infrastructure enhances workers' labor productivity , and this effect is known as the indirect productivity effect;
- The impact of infrastructure on regional economic growth is obtained in the initial period of its construction and modernization: many jobs are created in the construction industry and related services. Given that investments in infrastructure need operation and maintenance, the positive impact still fits in the long-term creation of jobs;
- Infrastructure also has a positive effect on the outcomes in education and health : better health facilities and labor with a higher level of completed education will further induce growth.

Another issue of methodology is the mathematical modelling of the correlation between infrastructure and economic growth. In the specialty literature we may distinguish at least four main mathematical economic approaches to measure the impact of public capital investment or of infrastructure resources on economic growth.

The most common approach is based on a function of production. Here, a functional form - such as the Cobb-Douglas - is chosen for the production function and the production function is estimated empirically later on.

The so-called behavioral approach would estimate a cost function or a profit function that includes the public capital stock. This allows for the use of more flexible functional forms and keeps somewhat better account of the different characteristics of public capital in relation to the private capital.

The models of Vector Auto Regression (VAR) type try to solve some of the problems of causality and endogeneity related to the first two approaches, by imposing as few as possible of the economic restrictions.

An alternative way of modeling the effects of increasing public capital investment is to include government investment expenditures in cross-section regressions of economic growth (cross-regional, cross-country).

While each approach has its own set of merits, as well as its limits and problems, the striking issue is that general research conclusions derived from these different approaches are surprisingly similar (Straub S., Akiko Terada-Hagivara, 2011).

Most of the commented channels of economic growth discussed in this context may be represented in a generic form by a production function such as:

$$Q = A(\theta, KI), F(K, L, G(KI)),$$

where Q is the gross real product (GDP), K is the aggregate capital (non-infrastructure), KI is the infrastructure capital stock, L is the gross number of hours worked by labor and A(.) is a standard productivity term.

The KI infrastructure capital is included also in the production function F(.), through the function G(KI). As such, infrastructure in this formula can be simply regarded as an additional factor of production ($G(KI) = KI$), as it is often in the macroeconomic literature (Romp and de Haan, 2005). This implies that the stock of infrastructure has pure public good attributes and provides non-rival and non-exclusive services.

We can say therefore that most economic growth approaches to measure the impact of infrastructure, do employ the standard production function with complementary factors of production, so the growth of the capital stock of infrastructure would have a direct effect of increasing the productivity of other factors. Empirical applications will measure the impact of infrastructure capital by estimating the elasticity of output (GDP, production, etc..) depending on some infrastructure input.

3. Challenges in analyzing correlation between infrastructure and economic development

3.1. Characteristics and results concerning methodological issues and empirical estimates of the correlation

In modern studies and research, infrastructure is seen as the basic physical structure consisting of: transport infrastructure, water supply and sewage sanitation infrastructure, telecommunications and energy infrastructure. This is considered public infrastructure that creates benefits for a large number of users.

The authors of the literature provide few reasons for choosing a particular stock of assets and for defining infrastructure components. There is no actual agreement on a single set of namely infrastructure variables among researchers: the main trends in the literature are either of grouping all infrastructure sectors, or to study a type of infrastructure, especially that of transport, and to ignore any relationship between different types of infrastructure. Researchers seek to use for public infrastructure physical indicators rather than monetary indicators, on the ground to avoid the difficulty of assessing the infrastructure capital, because there is no definitely agreed methodology for assessing the infrastructure variables (Snieska V., Simkunaite I., 2009).

Therefore typically it shall be considered that the infrastructure capital consists of several sub-areas which may be each defined by a set of physical variables: transport infrastructure (length of public roads, railways, etc.); water and wastewater infrastructure (resident population connected to water supply and sanitation services and systems); telecommunications infrastructure (number of telephone lines etc.); electricity infrastructure (power plants, transmission and distribution lines). Most recent studies and research, taking into account European or medium developed countries, refer mainly to transport infrastructure, the electricity and telecommunications, as factors of economic development.

One of the most interesting mathematical economic models of the effect of infrastructure development on GDP size, namely on economic growth is the one proposed by professors David Canning and Esra Benathan in the study "The Social Rate of Return of Infrastructure Investments" (published in 2002) within the international research project under the auspices of the World Bank "Infrastructure and Growth: a multicountry Panel Study" (RPO 680-89). The model is special, as it aims to better or more completely estimate the return on investment in infrastructure, on the assumption that cost-benefit analyzes of specific projects can not capture all the externalities and the macroeconomic impacts of these investments.

To examine and estimate the contribution of infrastructure to the aggregate output, in their cross-country panel research, the approach suggested is a so-called common world-wide production function, given by the equation :

$$y_{it}=a_i+b_t+f(k_{it},h_{it},x_{it})+\varepsilon_{it} \quad (1)$$

where: y is log output per worker; a is a country specific level of total factor productivity; b is a time dummy capturing world-wide changes in total factor productivity; k , h and x represent the log of per worker inputs of physical capital, human capital, and infrastructure capital respectively; term ε represents a random error; i and t are the country, respectively the time indexes.

However, the authors warn from the very beginning of the mentioned study that a main problem with estimating these function is reverse causality, since “ An increase in income leads to increased demand for infrastructure, and so a positive correlation between infrastructure stocks and output levels may be simply due to increased demand, and may not reflect any supply side productivity effect ”(Canning D., Bennathan E., 2002). Thus, one main challenge in analyzing the correlation between infrastructure and economic development is the presence of a probable and potential reverse causation, between the size of the GDP and the investment in infrastructure. This may generate an error in the sense of a surplus for the estimated coefficients.

Therefore, taking this into account, some authors : Straub (2011), Romp and de Haan (2005) have concluded that GDP elasticities depending on the public capital stand at most between 0.1 and 0.2. Likewise, Calderón et al. (2011) estimate the elasticity of output according to public infrastructure, to be between 0.07 and 0.10.

There are now concerns about the importance of development in public infrastructure, including water and sanitation, in some new member states of the European Union, wishing to maximize efficiency and positive socio-economic assistance from the Structural and Cohesion Policy in order to accelerate the convergence process.

A recent and inspiring study is “Socio-Economic Impact of Infrastructure Investments” by Snieska and Simkunaite (2009). Based on a thorough literature review as well as on their own research and experience, these authors also identify some conceptual and methodological limits and challenges in analyzing correlation between infrastructure and economic development : „Lack of unique methodology in academic literature hinders evaluation of the infrastructure investments impact on social and economic development; Characteristic of each country determines the set of infrastructure components and the aspect of impact on social and economic development: economic growth, income inequality, output, regional competitiveness, labor productivity and welfare.”

Their paper presents scientific approaches on the contribution of infrastructure factors and provides empirical test of the impact of infrastructure on the level of economic development in the Baltic states: Lithuania, Latvia and Estonia. The study has sought to emphasize, based on the statistical and mathematical data processing for the correlation and regression analyzes, the impact of the three sub-sectors of infrastructure represented by the chosen proxy variables, on economic growth in each country (of the three Baltic states).

Given the recent international practice, correlation and regression analysis is based on physical indicators for infrastructure as proxy explanatory variables (statistics from Eurostat and World Development Indicators database): paved road length in kilometres per 1000 people; fixed line and mobile phone subscribers per 1000 people; resident population connected to wastewater collection and treatment.

The results and empirical estimates suggest the following conclusions and interpretations of economic analysis: in the case of Lithuania, only the variable that approximates the transport infrastructure has a positive impact on GDP per capita. The correlation between the other infrastructure subsectors, namely the telecommunications and the sanitation (sewerage and wastewater treatment) and the determined variable GDP per capita is negative. In the case of both Latvia and Estonia, the situation is different: there is a strong positive correlation between transport and telecommunications infrastructure and per capita GDP growth, but growth correlation with the variable related to sanitation is still negative in both these countries.

The main conceptual and methodological limitations or challenges that have emerged from the analysis of this research can be summarized as follows: the definition of infrastructure and its structure, methods of variable measurement and the model of relationship evaluation are the main factors for accurate testing of the impact of infrastructure investments; the empirical test proved that the model of infrastructure impact evaluation must involve determinants of regional peculiarity; the statistical measurement of relationship between infrastructure and

economic growth determinants in the Baltic States proved that several variables are not enough to evaluate the impact of infrastructure on development (Snieska and Simkunaite ,2009).

3.2. Issues and challenges for analyzing the correlation between the water infrastructure and economic development in Romania

Although during 2001-2011, Romania had the highest rate of public investment expenditure as a share of GDP (Romania Fiscal Council, 2012), other new EU member countries such as Poland, Hungary, Bulgaria, Slovakia and Slovenia, with lower investment costs, have a better infrastructure quality, which demonstrates the low efficiency of these expenditures for Romania.

Unfortunately, water infrastructure is a real similarity between Romania and the countries and poor regions of Asia and Africa, considering just the poor level of development of water supply and sanitation networks, especially of the wastewater sewerage and treatment facilities, and hence the relatively low access of the population to these public infrastructure services: nationally, only 56% of the total population is connected to public water supply while less than 50% is connected to wastewater collecting systems, with some regional variations (table 1).

Table 1 Water supply and sanitation infrastructure and economic development indicators in the development regions of Romania (year 2011)

Development regions in Romania	GDP/capita (Euro)*	Population connected to public water supply (% of total county population)**	Population connected to wastewater collecting systems (% of total county population)**
North-West	5342	60.05	42.65
Center	5961	61.66	50.63
North-East	3850	39.74	31.31
South-East	5138	60.25	45.32
Bucharest-Ilfov	14404	79.34	81.42
South-Muntenia	5160	52.45	28.39
South-West Oltenia	4755	44.49	32.86
West	6979	64.88	49.59
TOTAL	6150	56.45	43.51

Source: * Data from the National Commission for Economic Forecasting, The spring forecast 2013 **Own calculations based on raw data from the N.I.S. database TEMPO-online ENVIRONMENT PMI109A and PMI109B

After studying and analyzing the studies, theories, models and empirical results from the literature at international and European level, we observed that, in addition to the general limits and shortcomings of conceptual, methodological and empirical character, there is the drawback that Romania was not generally included in studies and data panels to estimate the empirical results on the correlation between infrastructure (particularly water supply and sanitation infrastructure) and economic development.

On the other hand, we believe that there are some reasonable grounds for the omission of our country in the samples of data of the international studies :

- The fact that Romania is not part of OECD countries;
- The fact that Romania is only a relatively recent (since 2007) Member State of the European Union, so the country has not benefited of major FSC (Structural and Cohesion Funds) financing, for a period of at least 10 years, which would have allowed the development of its infrastructure so as to cut back the important gap in this sector, compared to the EU average and the other Member States;
- In addition, as we have pointed out in previous publications, the current infrastructure underdevelopment (for the road transport, but also for the water supply and sanitation) in Romania, is simply dramatically lagging behind, so inconsistent to other EU countries. Therefore, inclusion of data for these variables from Romania in cross-country regression studies could introduce statistical distortions;

- Neither the time series are available for certain variables, except data recorded since 2006 (e.g. data on the collection, treatment and disposal of wastewater from Romania), a fact which does not yet provide long enough time series for the analysis and evidence of correlations and trends.

In an effort to overcome the obstacles and trying to demonstrate the importance of public infrastructure for sustainable economic development, we initiated some calculations for regression and correlation analysis. The statistical and mathematical research undertaken tried to capture the correlation between economic development (represented by the variable GDP / capita) and the development of water supply and sanitation (WSS) infrastructure, represented by different proxy variables, depending on available data in Romania: at the national level, through a regression analysis and correlation of data series on several variables for Romania, for a period of 12 years (1998-2009); at the European level, we considered a cross-country regression (of 2009, latest data available) for 25 countries in Europe, of the variable GDP / capita, as determined by the share (%) of total country population served by public water supply system, and by the share of population connected to sewage sanitation systems. Since the main outcomes, conclusion and comments on these two research results of these two research approaches have been already released in (Frone Simona Maria, Frone Dumitru Florin, 2012); we should detail here the last approach left.

For evidence on the influence of the water and sanitation infrastructure, on economic development at the regional (county) level in Romania, we considered cross- regression with data from 2011, for the 42 counties, of the variable GDP / capita, in correlation with the share of population (%) of total county population) served by public water supply system, respectively with the share of population connected to sewage systems. In doing so, we have used statistical data and estimates of National Institute of Statistics and the National Commission for Economic Forecasting (the same sources as of Table 1).

Variables considered in the modeling were: the determined variable: county GDP per capita (in Euro, 2011), denoted JUD1; the explanatory variables (proxy for the level of WSS infrastructure development): Population served by public water supply system (% of total county population), denoted CPWS variable; Population connected to sewerage systems (% of total county population), a variable denoted CSAN. In the following approach, the LOG function represents a natural logarithms procedure used to normalize the variables. The brackets below the estimated coefficients show the values of their t-Statistics.

After the automated processing of these data sets, we obtained the following results, hence the regression equations (details are given in Appendix A):

$$\text{LOG (JUD1)} = 0.49877\text{LOG (CPWS)} + 6.58236 \quad (2)$$

$$R^2 = 0.26313 \quad (3.77944) \quad (12.74388)$$

The regression equation shows that in Romania there is a positive correlation between access to the public water supply and economic development at the regional (county) level, although there are of course other drivers that do not appear in the regression equation above; statistical and probability tests applied seem to validate the estimated coefficients of the regression equation and the correlation shown (details of the estimation output in Appendix A.1)

$$\text{LOG(JUD1)} = 0.57177\text{LOG(CSAN)} + 6.47284 \quad (3)$$

$$R^2 = 0.39449 \quad (5.10494) \quad (16.00473)$$

We note that regression equation (3), which is better than the previous one in terms of a higher coefficient of determination, shows that in Romania there is a positive correlation between access to the public wastewater sewerage network and economic development at the county level (of course there are other determining factors that are not in the regression equation above; therefore, the coefficient of determination is of only 0.39). Here again, statistical and probability tests applied seem to validate the estimated coefficients of the regression equation and the correlation shown (details of the estimation output in Appendix A.2)

The implication is that the development of sewerage (wastewater collecting) infrastructure and so an increase in the share of population connected to this service can lead to economic growth (GDP growth / capita) at the regional (county) level. The elasticity coefficient (0.57177) however, is debatable, but it is certain that the coefficient is different from zero and positive, as shown by all statistical tests and probabilities attached to the estimated coefficients which validate the regression equation and the correlation shown.

$$\text{LOG}(\text{JUD1}) = 0.02227\text{LOG}(\text{CPWS}) + 0.55501\text{LOG}(\text{CSAN}) + 6.44621 \quad (4)$$

$R^2 = 0.39468$ (0.10939) (2.91121) (13.53083)

By introducing both proxy variables for water infrastructure (CPWS for water supply, respectively CSAN for sewerage sanitation) in the regression equation (4), there is only a minor increase in the determination coefficient R^2 , but a relative change in the regression coefficients, which should better approximate the influence of these variables on county economic development in the period under review, although the meaning of influence (positive) is maintained. (Details of the estimation output in Appendix A.3).

In addition, we observe that the estimated coefficient of the variable LOG (CSAN) stays almost unchanged from the previous estimated in regression equation 3, remaining robust to a value of 0.5, and t-statistic significant. In contrast, there is a drastic reduction in the coefficient of the variable LOG (CPWS), which becomes also insignificant t-statistic.

This can be explained, in our opinion, by the fact that sanitation is much less developed than the water supply network in Romania (especially in rural areas), and currently investment efforts are primarily made to extend the sewerage network and for the construction of wastewater treatment plants, in order to comply with the implementing of Directive 91/271/EEC concerning urban waste water treatment.

Also, as expected from the theoretical channels of growth mentioned, larger access to sanitation and sewerage infrastructure may have a positive impact on the total factor productivity in the region, due to increased business or technology opportunities and higher labour productivity.

4. Conclusions

Ever since we developed the doctoral thesis on the topic: Public and private investments as factors to revive economic growth in Romania, we have concluded on the still irreplaceable while disputed importance of public investment and capital in the market economy. The main arguments were plowing about the indispensability of essential public goods for sustainable economic development: education, research and development, infrastructure and environmental protection. Yet, in recent years, the overall incidence and impact of unprecedented economic and financial crisis have led to the revival of Keynesian theories on the role of state intervention and public works to avoid or mitigate recession and support sustainability of economic growth.

On this theoretical background, the postdoctoral research also aimed to continue, customize and confirm for Romania, the main recent contribution in the theoretical and methodological grounding of the correlation between water infrastructure and socio-economic development (Grey D., Sadoff Claudia, 2006).

One of the methodological approaches was the estimation and analysis of the simple cross-county regression equations described in this paper, as to estimate and validate the empirical correlation between the development of infrastructure for water supply and sanitation, on the one hand, and economic development (expressed as GDP per capita) at the county regional level in Romania, on the other hand.

We found robust evidence only on the positive correlation between the shares of the county population connected to the wastewater sewerage (sanitation) network and regional economic growth. This eventually supports our endeavor in demonstrating the importance and opportunity of implementing the investments in WSS infrastructure in Romania, with European Structural and Cohesion funding.

Still, there are methodological and conceptual challenges to be approached in future research, as linked, for instance, to the accurate estimate of the elasticity coefficients of the explanatory infrastructure variables, the use of monetary indicators for infrastructure capital and to the consideration of reverse causality.

Appendix A

A.1. Cross-county regression equation (2) output

Estimation Equation: $\text{LOG}(\text{JUD1}) = C(1) * \text{LOG}(\text{CPWS}) + C(2)$

Substituted Coefficients: $\text{LOG}(\text{JUD1}) = 0.498771076143 * \text{LOG}(\text{CPWS}) + 6.58236755099$

Dependent Variable: LOG(JUD1)
 Method: Least Squares
 Date: 09/11/13 Time: 17:29
 Sample: 1 42
 Included observations: 42

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(CPWS)	0.498771	0.131969	3.779445	0.0005
C	6.582368	0.516512	12.74388	0.0000
R-squared	0.263137	Mean dependent var		8.527431
Adjusted R-squared	0.244716	S.D. dependent var		0.327404
S.E. of regression	0.284537	Akaike info criterion		0.370541
Sum squared resid	3.238452	Schwarz criterion		0.453287
Log likelihood	-5.781359	Hannan-Quinn criter.		0.400871
F-statistic	14.28420	Durbin-Watson stat		1.438178
Prob(F-statistic)	0.000513			

A.2. Cross-county regression equation (3) output

Estimation Equation: $\text{LOG}(\text{JUD1}) = \text{C}(1) * \text{LOG}(\text{CSAN}) + \text{C}(2)$
 Substituted Coefficients: $\text{LOG}(\text{JUD2}) = 0.576804573105 * \text{LOG}(\text{CSAN}) + 6.45015800725$

Dependent Variable: LOG(JUD1)
 Method: Least Squares
 Date: 09/11/13 Time: 19:56
 Sample: 1 42
 Included observations: 42

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(CSAN)	0.571774	0.112004	5.104949	0.0000
C	6.472842	0.404433	16.00473	0.0000
R-squared	0.394495	Mean dependent var		8.527431
Adjusted R-squared	0.379357	S.D. dependent var		0.327404
S.E. of regression	0.257932	Akaike info criterion		0.174203
Sum squared resid	2.661148	Schwarz criterion		0.256949
Log likelihood	-1.658264	Hannan-Quinn criter.		0.204533
F-statistic	26.06051	Durbin-Watson stat		1.476042
Prob(F-statistic)	0.000008			

A.3. Cross-county regression equation (4) output

Estimation Equation: $\text{LOG}(\text{JUD1}) = \text{C}(1) * \text{LOG}(\text{CPWS}) + \text{C}(2) * \text{LOG}(\text{CSAN}) + \text{C}(3)$
 Substituted Coefficients: $\text{LOG}(\text{JUD1}) = 0.0222759773936 * \text{LOG}(\text{CPWS}) + 0.555010195876 * \text{LOG}(\text{CSAN}) + 6.44621215611$

Dependent Variable: LOG(JUD1)
 Method: Least Squares
 Date: 09/11/13 Time: 20:03
 Sample: 1 42
 Included observations: 42

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(CPWS)	0.022276	0.203626	0.109397	0.9134

LOG(CSAN)	0.555010	0.190646	2.911210	0.0059
C	6.446212	0.476409	13.53083	0.0000
R-squared	0.394680	Mean dependent var		8.527431
Adjusted R-squared	0.363638	S.D. dependent var		0.327404
S.E. of regression	0.261177	Akaike info criterion		0.221515
Sum squared resid	2.660331	Schwarz criterion		0.345635
Log likelihood	-1.651821	Hannan-Quinn criter.		0.267010
F-statistic	12.71438	Durbin-Watson stat		1.474131
Prob(F-statistic)	0.000056			

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