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Multi-sectoral interdependencies of regional public infrastructure investments

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ABSTRACT

Public investment decision-making processes involve multiple and interrelated sectoral and regional policy objectives and budget constraints. This paper presents a dynamic spatio-economic model that considers multi-sectoral investment interdependencies using data at the prefecture level in Greece. The expenditure allocation dynamics of most types of regional public investment are found to be competitive with each other. This outcome is attributed to the lack of policy coordination, technological and budget constraints, geographical factors, and equity and political considerations. The investment interrelationships may have a significant effect on future state funding needs and the strategic assessment of infrastructure development at the country level.

1. Introduction

Regions become increasingly interdependent at various spatial scales and sectoral levels as well as reliant on interregional flows of labor and resources. At the same time, the interdependencies among various infrastructure systems are intensified by technological advances, shifts in production and consumption patterns and the need to fulfill capacity requirements of rapid urbanization and the renewal of aging infrastructure networks. In the policy context, fiscal and planning measures are considered to foster the geographic concentration of infrastructure in different sectors and induce productivity gains from agglomeration economies. Examples include the European Commission initiatives "Connecting Europe" and "Smart Cities and Communities", and Smart Grid systems, to jointly promote network infrastructure investment. In the new programming period 2014–2020, such coordination schemes are expected to upgrade and interconnect transport, energy and information and communication technology (ICT) networks [16].

The coordinated infrastructure development, yielding integrated or 'package' policies at the national and regional level, can be regarded as a critical factor for attracting more public as well as private investments. The potential synergetic relationships among policy measures can significantly increase both the effectiveness and efficiency of investments and other policy interventions, mitigating unintended effects and conflicts across institutional contexts and jurisdictional scales [19]. The public investment complementarities among sectors can be viewed within the broad context of policy complementarities, which refers to the mutually reinforcing impact of different (investment and other) actions on a given policy outcome [15]. The lack or failure of policy coordination potentially results in the loss of value-added synergetic interrelationships, or the emergence of competitive interrelationships, which can give rise to additional administrative and investment costs (negative fiscal externalities). Nonetheless, the extent to which investment policy coordination mechanisms are actually in place is often unclear.

The problem of public expenditure interdependencies has been typically addressed by use of intuitive judgment or some crude policy guidelines [31]. These rely primarily on intense political negotiations, without employing formal economic analysis within a systemic methodological/modeling framework. Initial attempts included in the literature primarily sought to evaluate intersectoral investment allocation based upon cross-country, time series regression analysis of growth, by adopting the same criteria to those used for intra-sectoral allocations [26]. Such criteria usually concern the role of government versus the private sector, cost-benefit analysis and equity impacts.

The availability of enriched datasets from the central government has fueled quite a few country-level analyses of investment allocations involving multiple expenditure categories, particularly in the transport sector. Lindsey [20] describes examples of strategic decisions of public investment allocation on transport infrastructure. Especially, in Singapore, central government investment decisions reflect as over-investment in airport and mass rapid transit

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systems to prevent competing investments [3,25]. Except for the competition and/or cooperation between regions for the design and implementation of public investments of the same type, such relationships should also be considered and tested for investments of different types within a specific sector (e.g., transport)[1] as well as among different sectors.

Existing studies have focused on examining these relationships among broad categories of capital spending (for physical and social infrastructure). For example, negative tradeoffs have been identified between military (so-called nonproductive) spending and economic and social investments and well-being [5,12]. Nagurney and Dong [24] proposed the concept of 'super-networks' to capture interactions among transport, telecommunication, energy, and financial networks. Although this modeling framework is well defined using generalized network theory and variational inequalities, its calibration and application issues are not sufficiently addressed. Zhang and Peeta [32] developed a multilayered network model with market-based interactions to examine investment interdependencies among network industries. However, such types of models do not have a sound explanatory power to interpret the causality of the underlying interdependencies for policy purposes.

The problem is addressed here through the development and implementation of a dynamic spatio-economic model with multisectoral interdependent resource allocation at the country level. The proposed model can be validated, explain causality and explicitly incorporate budget constraints, allowing for fiscal spillovers among sectors. Its main objective is to provide a systemic framework for (a) identifying public investment interdependencies among different sectors of the economy, (b) helping to address conflicting investment strategies, and (c) supporting the ongoing and ex-post evaluation of sectoral fiscal externalities among regional investments, in order to achieve intended policy outcomes, as outlined by the EU and the national government. Section 2 describes the model; Section 3 presents the data; Section 4 shows and analyzes the results, and Section 5 summarizes and concludes the policy implications of the empirical findings.

2. Spatio-economic model of public investment interactions

The proposed model builds on the dynamic spatio-economic model of regional competition of [13,14]; as it was modified by Tsekeris [28] to consider substitution/complementarity relationships of public investment in the transport sector at the country level. The latter model is extended here to examine the public investment interdependencies among all economic sectors, in terms of various expenditure categories (or category groups), and the effect of budget constraints.

Let y_{mr}^{t} denote the relative public spending (share), with regard to the total spending in all sectors M, for investment type (or category) m at a specific region r and time t. Also, let us assume that there are M types of investment (by sector) in that region. The expression of shares signifies that: (i) expenditures can relatively vary (in a synergistic or competitive manner) among sectors and prefectures, and (ii) they are subject to budget constraints, either at the sectoral or the national level. The assumption of an exogenous budget constraint can be considered as plausible in the present study, since the total budget of a programming period as well as the share of this budget for each type of investment are generally known in advance. On a yearly basis, the budget allocated from national sources (Public Investment Program) (see Section 3) is largely earmarked and typically fixed, while that from EU fund sources may also be regarded as exogenous, for simplicity purposes, as representing the maximum amount of expenditure that can be absorbed by and allocated to all sectors and specific groups of investment categories.

The model follows a log-linear panel data formulation, which allows expressing both the spatial and sectoral variability of expenditure shares. Also, it controls for problems of omitted variables and heterogeneity, incorporating time- and prefecture-specific fixed effects. By extending the intra-sectoral competition model of Tsekeris [28], the public investment allocation can be considered as a discrete system of distributional dynamics among economic sectors with budget constraints, which is specified as follows:

$$\begin{aligned}\ln y_{mr}^{t+1}-\ln y_{1r}^{t+1}=&\ln A_m+\sum_{k=1}^{M'}a_{mk}\ln y_{kr}^{t}+\sum_{n=1}^{N}b_{nr}Z_r^t\\&+\eta_{mr}S_r+\theta_m^t L^t+u_m,\ m=2,3,\ldots,M';\\&k=1,\ldots,M';r=1,\ldots,R;t=1,\ldots,T\end{aligned}\tag{1}$$

subject to $\sum_{k=1}^{M'}\sum_{r=1}^{R}y_{kr}^{t}=1$, with $M'\le M$, and $0<y_{kr}^{t}<1$, $k=1,\ldots,M';\quad r=1,\ldots,R;\quad t=1,\ldots,T$

The above specification is simplified to include two cases: $M'=M$, where all sectors are considered in the analysis subject to the national total fixed budget, and $M'<M$. In the latter case, M' denotes a group of sub-sectors (here, it refers to those composing the transport sector). This constraint signifies that the total share corresponding to that group remains fixed (per annum) throughout the period of analysis. The suggested modeling framework intrinsically implies a complementary or competitive relationship between (distinct groups of) expenditure categories, whose overall budget is considered to be fixed and which seek to obtain the maximum possible share. This is in accordance with a zero-sum game, in which the growth in one agent (sector) takes place at the expense of, at least, one other, so that they balance the total budget in the period of analysis. Nonetheless, the present specification and analysis can be extended to encompass more than two distinct expenditure groupings, even involving more types of sectoral and temporal budget constraints. In the latter case, alternative (dynamic and repeated) game-theoretic formulations may be adopted to demonstrate the endogeneity of the budget constraint in some year, due to the grants absorbed and allocated in previous years for a specific group of investment categories.

The constant coefficient $A_m > 0$ denotes the comparative advantage of investing in sector m. A positive (negative) value of elasticity coefficient a_{mk} indicates complementary (competitive) growth in expenditure shares between the two types of investment, m and k. The elasticity terms a_{mk} may incorporate the impact of a set of interrelated or conflicting policy objectives of multiple agents (stakeholders) at various (sectoral and spatial) levels of decision-making. The resulting pattern of interaction and its significance would rely on which policy or technological forces of a specific agent will mostly prevail over (or cooperate with) the others. On the one hand, a strategic investment in one sector may target at agglomerating infrastructure investments in other sectors in a specific region, e.g., through exploiting reductions in transport cost, input sharing, knowledge spillovers and scale economies. On the other hand, the net effect of a strategic investment on the other (targeted) types of investment at the country level could be negative (as would reflect the sign of a_{mk} coefficient), e.g., due to asymmetric changes in interregional accessibility and the production structure of the whole spatial economy.

The usage of numeraire (here, denoted as investment type 1) enables the modeling of the investment share in a specific category

[1] For instance, the Latin American transport projects [7], the Asian-Pacific transport corridors [27] and the Trans-European Transport Network (TEN-T) projects [4,30].