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An Impact Evaluation of Investment in Infrastructure: The Case of the Railway Connection in Uzbekistan

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Abstract

The objective of this paper is to examine the nature and magnitude of the effects of infrastructure provision on regional economic performance. The empirical evidence of our analysis is based on difference-in-difference estimation linking the changes in the growth rate of regional-level economic outcomes in affected regions to the newly built railway connection in the southern part of Uzbekistan, conditioned on the regions' time-invariant individual effects, time-varying covariates, and evolving economic characteristics. To explore the differential nature of infrastructure provision, we employ an estimation examining regional, spillover, and connectivity effects from the railway connection, as well as the anticipation, launch, and postponed effects of such a connection. Our empirical results suggest that the Tashguzar–Boysun–Kumkurgon railway line in Uzbekistan encouraged an increase of around 2% in the regional gross domestic product growth rate in affected regions in the frame of connectivity effects. This seems to have been driven by increases in industry value added and services value added of approximately 5% and 7%, respectively. Positive and significant changes in the industrial output of the directly affected and neighboring regions mostly took place during the design and construction period in anticipation of the railway connection. The impact on agricultural output has been moderate in comparison to the abovementioned sectors, constituting around 1%, which is consistent with previous literature on the differential impact of public capital. Our results and the framework provided might help regulatory bodies to conduct comprehensive estimations of the impact of infrastructure and develop the formulation of both promotional and compensatory measures related to or induced by the effects of infrastructure provision.

JEL Classification: H54, O11, O23, R11

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1. INTRODUCTION

Defined as the basic physical and organizational structures and facilities needed for the successful operation of a society or enterprise, infrastructure affects economic activity in at least three ways. First, the quantity and quality of infrastructure supply, for example in terms of electric power or clean water in a region, directly affect investors' decisions in terms of whether or not to launch a business, which then translates into variations in the income levels of households, the tax revenues of the state, and the general economic performance of the region.[1] Second, improvements in information and communication technology infrastructure induces growth in the numbers of mobile and fixed-line telephone subscribers, as well as internet users, which significantly and positively affects the rate of economic growth through improved productivity and the elimination of information asymmetry. Third, the provision of new infrastructure in the form of paved roads and railway connections creates new opportunities for expanding the goods market for firms and the job market for labor, bringing the market closer to economic agents through better accessibility and improved mobility. If, as mentioned earlier, resource allocation across regions, with and without particular types of infrastructure, is different, there should be underlying systematic differences in many dimensions that cumulatively affect economic outcomes.

This paper investigates the effect of infrastructure provision on the economic outcomes of the regions affected by new infrastructure facilities. This empirical evidence, obtained by employing a difference-in-difference approach with the interrogation of commonly accepted assumptions on timing and the points of impacts, takes advantage of a multitude of perspectives and a unique data set created for the purposes of the study.

We examine the impact of railway connections on the gross domestic product (GDP) growth rate and sector value added of regions in the context of Uzbekistan, a Central Asian country, which—along with other economies in transition—has gradually been reforming and rebuilding its own integrated railway connection system since the collapse of the Soviet Union in 1991. Our identification of the causal contexts explains the variation in the growth rates of the economic outcomes according to the exposure of regions to the positive effects of the newly built railway connection, allowing regions to be classified into three categories based on how they were affected. The questions we address are as follows: (1) Did the changes, driven by the introduction of the new railway connection, significantly affect the economic performance of the regions exposed to them compared with those that were not? (2) Are there any spillover or connectivity effects across regions caused by the new railway connection?

Similarly, it is nearly impossible to prove definitively how a railway connection might affect economic outcomes or capture all the perennial effects derived from such a connection.[2] Nevertheless, this does not lessen the degree of policy relevance in

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[1] Wang and Wu (2012), in examining the high-altitude railway connecting the province of Qinghai to the Tibet Autonomous Region as a natural experiment, found a 33% increase in GDP per person in counties that were affected by the railway connection in comparison to those that were not.

[2] Schumpeter (1961: Chapter I) explains that the concept of economic development is an object of economic history that is "only separated from the rest for purposes of exposition," and concludes that "because of this fundamental dependence of the economic aspect of things on everything else, it is not possible to explain economic change by previous economic conditions alone." Consequently, the same is true for subsequent impacts, because "heteronomous elements generally do not affect the social process

understanding whether and how infrastructure provision influences regional economies within a country. Understanding the performance of infrastructure projects is important for central governments for reviewing the economic viability of future infrastructure projects arising from budgetary constraints. This is a particularly sensitive issue in developing countries with underdeveloped internal capital markets, as the demand for infrastructure finance in middle- and low-income countries always outweighs the supply of available funds. Evaluating the exact magnitude and significance of the impact of a particular type of infrastructure on economic outcomes can be of interest for multilateral development agencies and donors targeting investment in infrastructure projects in developing countries.

The essential findings can be summarized as follows: The estimation results suggest that the Tashguzar-Boysun-Kumkurgon railway line encouraged an increase in the GDP growth rate in the examined regions of approximately 2%. This effect seems to be driven by an increase in industry value added and services value added, with estimates of approximately 5% and 7%, respectively. The impact on agricultural output has been moderate in comparison to the aforementioned sectors, constituting around 1%, which is consistent with previous literature on the differential impact of public capital (Yoshino and Nakahigashi 2000). Along with the varying impacts across space, time, and among sectors, our study presents counterintuitive results concerning the effect of railway line provision on regional economic performance: regions located at the far ends of the within-country railway system seem to experience statistically significant and growth inducing impacts on their economies in comparison with the regions where the newly provided railway line is actually located.

The rest of the paper is structured as follows. In Sections 2 and 3, we provide a brief review of the literature linking infrastructure to economic growth and give background information on the state of railway transportation in Uzbekistan. Section 4 is devoted to the explanation of the estimation strategy, which employs a difference-in-difference approach, and the assumptions to be made. Section 5 describes the data on Uzbekistan used in the analysis. Section 6 presents the estimation results by outcome variable and Section 7 summarizes the findings and provides conclusions.

2. LITERATURE REVIEW

The identification of the relevance of infrastructure to economic activity can be traced back to classic works in economics, such as by Adam Smith, Karl Marx, or Fredrick Hayek. Although the core views and paradigms of these authors concerning the principles or nature of economic issues might have differed drastically from each other, they were united in addressing the importance of infrastructure for economic activity.

Smith unquestionably understood the crucial difference between infrastructure capital and other forms of capital. He classified infrastructure capital into two types, “circulating capital” and “fixed capital,” defining the latter as that used “in erecting engines for drawing out the water, in making roads and wagon-ways, etc.” (Smith 2005). Going beyond the simple notification of the role of such capital, Smith provided clear examples of infrastructure’s impact on interactions between producers and customers, landowners and retailers, providing his justifications for infrastructure financing options. In a similar manner, Hayek described two kinds of production factors, denoting them as “economic permanent resources” and “non-permanent production goods” (Hayek 2007), the former constituting a proxy for infrastructure capital.

in any such sector directly…but only through its data and conduct of its inhabitants;…the effects only occur in the particular garb with which those primarily concerned dress them” (Schumpeter 1961: 58).

Surprisingly, most widely known models of economic growth theory formulated later, including the Harrod–Domar model of 1946, the Solow–Swan model of 1956, the Ramsey–Cass–Koopmans model of 1965, and the Lucas model of 1988, either missed or omitted the notion of infrastructure capital, although their models greatly improved our understanding of the role and interrelationship of capital, labor, human capital spillovers, and technological progress.

Thus, while the question of economic growth and its determinants was raised at the same time as the branching out of economics as a separate subject in the 18th century, it was not until 1989 that Aschauer exploited core infrastructure capital in his empirical work relating the provision of infrastructure in the post-World War II period to variations in economic growth in the United States (US). His provocative findings were considered to be seminal in empirical work and resulted in an explosion of the field, followed by both confirmatory (Eisner 1994) and counterfactual (Harmatuck 1996; Hulten and Schwab 1991) arguments. Inspired by growing debate on the impact of infrastructure initiated by Aschauer (1989), other estimations using proxies for public infrastructure capital were subsequently carried out using data for different countries (Arslanalp et al. 2010; Yoshino and Nakahigashi 2000). Due to data availability, most of these studies dealt with high-income countries.

One of the earliest empirical examinations of the economic effects of infrastructure using statistical data for Asian countries was conducted by Yoshino and Nakahigashi (2000), who employed a production function approach to examine the productivity effect of infrastructure for Japan and subsequently for Thailand, distinguishing the social capital stock by region, industry, and sector.[3] Their results suggest that the productivity effect of infrastructure is greater in tertiary industries compared to primary and secondary industries. In their sectoral analysis, they revealed greater impacts in the information and telecommunications, as well as environmental sectors. From a regional perspective, the effect of infrastructure provision seems to be greater in regions with large urban areas.

In addition to the aforementioned production function approach, a wide range of different approaches has been employed to explore the nature of infrastructure, including the use of dual cost functions or profit functions and vector autoregression approaches. As Pereira and Andraz (2013) note, the majority of these approaches have helped to address issues associated with estimating the magnitude and significance of the contribution of public capital to infrastructure, but cannot account for

[3] They also explained the transformation mechanism of infrastructure investment and economic growth, dividing its effect into so-called "direct effects" and "indirect effects." A direct effect is defined as an additional output due to an increase in marginal productivity, which occurs as a result of an increase in infrastructure. An indirect effect is described as an additional output due to increased labor and private capital input based on an increase in infrastructure.

In particular, the theoretical framework employed constitutes a trans-log-type production function in which infrastructure capital, private capital, and the labor force are included as factor inputs:

$$Y = f(K_p; L; K_g)$$

where Y denotes output, K_p is the private capital stock, L is the labor input and K_g is the infrastructure stock.

Relating the output to the aforementioned factor inputs, they estimated both the direct and indirect effects from infrastructure provision, expressed as follows:

$$\frac{dY}{dK_g} = \frac{\partial Y}{\partial K_g} + \frac{\partial Y}{\partial K_p}\frac{\partial K_p}{\partial K_g} + \frac{\partial Y}{\partial L}\frac{\partial L}{\partial K_g}$$

the possibility of structural change or breaks. In other words, there is a lack of general consensus on the economic impact of infrastructure investment, which might not only be due to the methodology chosen but also because of the sample periods covered or ignorance of the structural breaks such infrastructure might induce.

Randomized trial methods, or treatment effects methods, which are widely used in program evaluation in the context of development studies, offer solutions to the issue of total impact estimation. With the assumption of a common time path and the availability of pre-treatment and post-treatment data on outcome variables of interest, researchers can estimate the degree of departure from the counter-factual trajectory, which can be attributed to the provision of treatment, in this case some kind of infrastructure. In particular, the results of the impact evaluation of the People's Republic of China's National Trunk Highway System by Faber (2014) suggests that the network connections led to a reduction in GDP growth among peripheral counties, which were non-targeted or lay outside the network system. Similarly, Gonzalez-Navarro and Quintana-Domeque (2010) presented evidence on the impact of infrastructure on poverty reduction, where within 2 years of the infrastructure provision in the form of paved roads, households reacted with increased consumption of durable goods and the purchase of motor vehicles. Our study uses a similar approach, distinguishing the scope of analysis by timeframe, sector, and region for Uzbekistan.

Although the body of literature covering middle-income countries has started to grow in recent years, particularly studies related to the People's Republic of China (Faber 2014; Wang and Wu 2012; Ward and Zheng 2013) and some East Asian countries (Yoshino and Nakahigashi 2004) mainly driven by their remarkable growth and improvement in conditions with regard to data dissemination, empirical literature examining either the role of infrastructure and its differential impact on economic outcomes in the context of Central Asian countries is as yet limited. Our paper attempts to shed light on the performance of infrastructure, focusing on the case of a railway connection in Uzbekistan.

3. BACKGROUND

To understand the current state of the unintegrated railway system in Central Asia, one needs to know the history of its creation or how the development of the Central Asian Railway (CAR) took place. Construction of the CAR started in 1880 from Uzun to Ada in the western part of present day Turkmenistan, at Michael Bay of the Caspian Sea in the direction of Kizir-Arvat, through Ashgabat, Mary, Chardzhou, Bukhara, and Samarkand, later reaching Khavas, Tashkent, and the Fergana Valley in the eastern part of present day Uzbekistan. After the transformation of the Russian Empire into the Soviet Union, further construction of railway lines continued based on the objective of greater connectivity of the regions with the central parts of the country.

However, as they were part of the Soviet Union, the neighboring socialist republics were not considered foreign countries and in many cases a railway line in one country crossed the territory of neighboring republics to reach other parts of its own territory. For example, the central part of present day Uzbekistan, Khavas, was connected to the country's eastern regions in the Fergana Valley by a railway line crossing the territory of Tajikistan, with two stops at the towns of Khujand and Kanibadam before reaching the town of Kokand in Uzbekistan. The situation was the same for southern regions: the railway line connecting Tashguzar and Termez, two administrative divisions of Uzbekistan, passed through the northern territory of Turkmenistan, which was part of the Soviet Union at the time.

Subsequently, after the collapse of the Soviet Union and the establishment of customs procedures, the aforementioned design of the railway system created significant obstacles to mobility and connectivity across the newly independent countries. As a result, each post-Soviet republic faced the challenge of adjusting its disjointed railway lines and paved inter-city roads to form a single within-country system.

In its efforts to achieve this goal, the Government of Uzbekistan has taken a gradual approach to infrastructure creation. Among the government measures directed toward improving the transportation infrastructure, four major projects should be outlined: (i) the repair and construction of the A-373 Tashkent–Osh highway connecting Tashkent, the capital city, with the Fergana Valley in the eastern part of the country; (ii) the construction of the Navoi–Uchkuduk–Sultan Uvaystog–Nukus railway line connecting the northern part of the country to the center; (iii) the construction of the Toshguzar–Boysun–Kumkurgon railway (the project examined in this study), linking the southern Surkhadarya region to the single within-country railway system and avoiding double customs procedures in Turkmenistan; and (iv) the current construction of the Angren–Pap electrical railway line, which will connect the unintegrated railway system of the eastern regions in the Fergana Valley with the Tashkent region, avoiding customs procedures due to crossing the territory of Tajikistan and as a result providing railway mobility across all regions of the country.

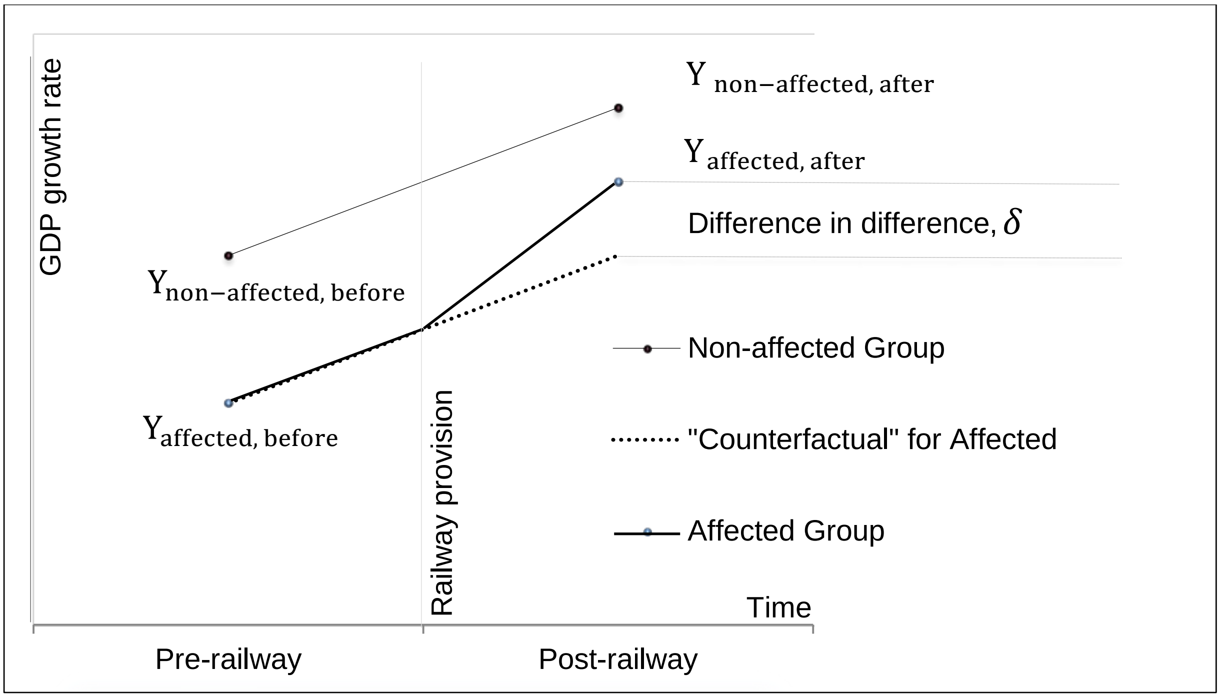
4. METHODOLOGY

For the purposes of our analysis, we are interested in capturing the economic dimension of infrastructure provision, in particular the variations in outcome variables affected by the introduction of a railway connection. To accomplish this, we employ a difference-in-difference approach. This approach allows estimation of the difference between the observed “actual” outcome and an alternative “counter-factual” outcome.

To undertake this estimation, we need to divide the data into a control group and a treated group on a geographical basis and a time basis, making the difference between pre-intervention or baseline data and post-intervention data. A graphical illustration of the framework is provided in Figure 1. The crucial difference of our study compared to other studies is the interrogation of generally accepted assumptions about the division into these groups in the framework, both in cross-sectional terms and based on time series.

First, we look at the geographical context and estimate three impacts, which we denote as regional effects, spillover effects, and connectivity effects. The rationale for and definitions of the abovementioned impacts are described in later in this section. After providing the framework considering the geographical impact assumptions, we check for outcome variations due to changes in the assumptions in terms of timing. We look at the anticipation effects, launch effects, and postponed effects of infrastructure provision. The data are used to estimate the impact of the TBK railway line launched in 2007–2008 in the southern part of Uzbekistan on the economic outcomes of the affected regions in the period 2009–2012, as represented by regional GDP and its components: agricultural value added, industrial value added, and services value added.

Figure 1: Illustration of the Difference-in-Difference Method with the GDP Growth Rate Outcome Variable



GDP = gross domestic product.

Source: Authors.

As a probabilistic expression, the difference-in-difference coefficient can be computed as follows:

$$(\mathrm{E}[\Delta \mathrm{Y}_{\mathrm{it}}|\mathrm{i}=\mathrm{AG},\mathrm{t}\{2009{:}\,2012\}]-\mathrm{E}[\Delta \mathrm{Y}_{\mathrm{it}}|\mathrm{i}=\mathrm{AG},\mathrm{t}\{2005{:}\,2008\}])-(\mathrm{E}[\Delta \mathrm{Y}_{\mathrm{it}}|\mathrm{i}=\mathrm{NAG},\mathrm{t}\{2009{:}\,2012\}]-\mathrm{E}[\Delta \mathrm{Y}_{\mathrm{it}}|\mathrm{i}=\mathrm{NAG},\mathrm{t}\{2005{:}\,2008\}])=\delta \quad (1)$$

where E denotes the population averages, $\Delta\mathrm{Y}$ is the outcome of interest, i.e., the regional GDP growth rate of region i at year t. AG indicates that the region belongs to the group of regions affected by the railway connection and NAG denotes those not affected. δ is the difference-in-difference coefficient.

Numerically, using the sample analogue of the population means the difference-in-difference coefficient can easily be computed by observing the changes in the variable of interest over time in both groups and calculating their differences (Table 1).

Table 1: Numerical Estimation of the Difference-in-Difference Coefficient Using Regional Data for Uzbekistan for the Periods 2005–2008 and 2009–2012

Region Group	Outcome	Pre-railway Period	Post-railway Period	Difference
Non-affected group	Average GDP growth rate (%)	8.3	8.5	0.2
Affected Group	Average GDP growth rate (%)	7.2	9.4	2.2
				2.0

Notes: The affected group includes the regions of Samarkand, Surkhandarya, Tashkent, and the Republic of Karakalpakstan. The rest of the observations are included in the non-affected group.

Source: Authors' calculations.

In doing so, we control for time-invariant, region-specific effects to proxy the idiosyncratic features of a region proceeding from historical, cultural, and social development, and year-specific effects to capture the effect of changes in legislation or the overall business climate. However, changes in economic performance might be caused by a wide range of other factors besides infrastructure provision and the aforementioned effects. If the positive effects of those factors are not accounted for, our estimates might be upward (downward) biased by positive (negative) effects generated by other factor inputs. This difficulty is mentioned and documented in the program evaluation literature as an external validity problem (Banerjee and Duflo 2009; Ravallion 2009; Rodrik 2008). To overcome this problem, we need to acknowledge the factors behind the genesis of changes in the economic growth rate and control for time-varying covariates, such as investment share, labor force, terms of trade, and others. Incorporating time-varying covariates in the estimation framework and obtaining a linear projection of the variable of interest onto these factors provides us with the following definitions of affected groups and non-affected groups:

Affected group, $Y_{g=A}$

t=0 (before railway): $\Delta Y_{A0} = \alpha_{A0} + \gamma_{A0} + X_{A0}\beta' + \varepsilon_{A0}$ (2)

t=1 (after railway): $\Delta Y_{A1} = \alpha_{A1} + \gamma_{A1} + X_{A1}\beta' + \varphi_{A1} + \delta + \varepsilon_{A1}$ (3)

Non-affected group, $Y_{g=N}$

t=0 (before railway): $\Delta Y_{N0} = \alpha_{N0} + \gamma_{N0} + X_{N0}\beta + \varepsilon_{N0}$ (4)

t=1 (after railway): $\Delta Y_{N1} = \alpha_{N1} + \gamma_{N1} + X_{N1}\beta + \varphi_{N1} + \varepsilon_{N1}$ (5)

The regression framework allows us to control for the aforementioned covariates and obtain a less biased estimate of the difference-in-difference coefficient. Equations (1)–(5) allow us to derive the baseline estimation strategy of the difference-in-difference specification, which takes following form:

$$\Delta \mathrm{Y}_{\mathrm{it}} = \alpha_i + \varphi_{\mathrm{t}} + \mathrm{X'}_{\mathrm{it}} * \beta + \delta * \mathrm{D}_{\mathrm{gt}} + \epsilon_{\mathrm{it}} \quad (6)$$

where $\Delta\mathrm{Y}$ is the regional GDP growth rate, X denotes the time varying covariates (vector of observed controls), D is the binary variable indicating whether or not the observation relates to the affected group after provision of the railway line, i indexes regions, g indexes groups of regions (1 = affected group, 0 = non-affected group), t indexes treatment before and after (t=0 before the railway, t=1 after the railway), α_i is the sum of autonomous (α) and time-invariant unobserved region-specific (γ_i) rates of growth,[4] φ_t is the year-specific growth effect and ϵ_{it} is the error term, assumed to be independent over time.

The vector of observed controls, X, can be classified into micro- and macro-level factors. Macro-level factors are represented by government spending on education, health care, and research and development (R&D), where spending on health care is defined as the sum of expenditure and includes the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health, but excludes the provision of water and sanitation. Micro-level factors comprise the percentage of the working population (i.e., ratio of those aged 16–64 years to the total population), investment share by state and private sector (classified as population, enterprises, commercial banks, foreign investors, and off-budget funds) and terms of trade (ratio of total exports to imports in a given period).

To account for both time-invariant unobserved characteristics (e.g., the advantageous location of a region) and year-specific growth effects (e.g., favorable changes in the business climate), we use a fixed effects estimator. If we were to assume that such factors did not determine the nature of changes in the control variables, we could use a random effects estimator; however, this would ignore important information on how the variables change over time when region-specific characteristics are correlated with time-varying covariates.

Following Bertrand et al. (2004) with regard to possible autocorrelation within a region, we employ heteroscedasticity and autocorrelation consistent (HAC) standard errors, belonging to the class of cluster standard errors. HAC standard errors allow for heteroscedasticity and arbitrary autocorrelation within a region, but treat the errors as uncorrelated across regions, which is consistent with the fixed effects regression assumption of independent and identical distribution across entities, in our case regions i=1,…14.

As part of our sensitivity analysis, we execute non-hierarchical stepwise inclusion of additional variables such as initial services per capita, which is mainly based on convergence theory and might also explain the magnitude of the growth rate of a region. Furthermore, we employ various functional forms, including cubic and quadratic forms of the state's investment share. Post-estimation diagnostics in the form of testing the exclusion of variables were carried out for year fixed effects and the equality of the coefficients of the state investment share with the remaining three types was tested.

[4] This approach requires an assumption of a common time path or parallel trends, accepting the autonomous rate of growth α to be equal in both affected and non-affected groups.

4.1 Assumptions Concerning the Geographical Impact of Infrastructure Provision

In terms of the geographical context, first, we examine the assumption of a regional effect of infrastructure provision on economic performance in the location of the infrastructure, in our case the Surkhandarya and Kashkadarya regions of Uzbekistan. The literature provides empirical evidence of the testing of a similar hypothesis using a production function approach (Abidhadjaev and Yoshino 2013; Seung and Kraybill 2001; Stephan 2003; Yoshino and Nakahigashi 2000), a behavioral approach (Cohen and Paul 2004; Moreno, López-Bazo, and Artís 2003) and using vector autoregression approaches (Everaert 2003; Pereira and Andraz 2010), inter alia.

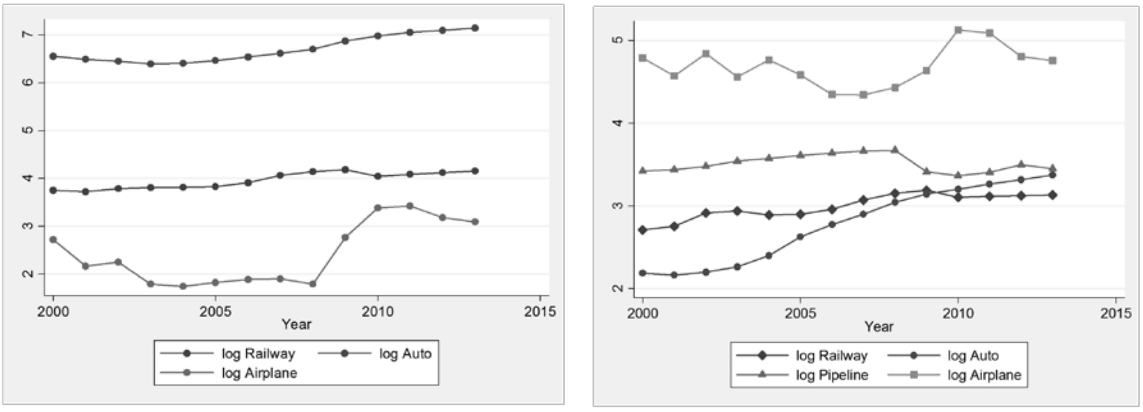
Second, quasi-experimental methods for the evaluation of the impact of a particular intervention usually require clear identification of the distinction between affected and non-affected groups (see Duflo, Glennerster, and Kremer [2008]). Inappropriate assignment of observational data into treated or control groups might result in complications in the objective and comprehensive assessment process. In this respect, the empirical literature can help us to explore different combinations of treated or affected groups based on patterns revealed through previously conducted studies. Consequently, proceeding from the analysis of Pereira and Andraz (2013), who revealed a pattern of negative or insignificant effects of infrastructure provision at the regional level (see also Yoshino and Abidhadjaev [2015]), and positive and significant effects at the aggregate level (Belloc and Vertova 2006; Pereira and Andraz 2005), we address the spillover effects of the railway connection on neighboring regions. Empirical evidence derived from the analysis conducted by Pereira and Andraz (2003) using a vector autoregression approach for transport and communications infrastructure and Pereira and Roca-Sagales (2007) for highways demonstrates positive spillover effects of infrastructure provision on neighboring regions.

Our third empirical context is based on empirical evidence obtained from the literature on transportation mode choice (Wang et al. 2013) and connectivity (Faber 2014). The first group of authors analyzed interstate freight mode choices between truck and rail in Maryland, United States, and found that longer distances contribute positively to the use of rail as a means of transportation. Similar evidence revealing the greater role of distance in choosing rail was earlier obtained by Jiang, Johnson, and Calzada (1999) using data for France, as well as by Beuthe et al. (2001), who computed the modal elasticity of Belgian freight by employing origin–destination (O–D) matrices and cost information. Based on these studies, we examine the connectivity effect of the railway connection by designating the regions located at the far ends of the within-country railway system as potential beneficiaries.

However, before proceeding with the third empirical context, we ensure that the pattern revealed in the aforementioned studies also applies to the case of Uzbekistan. To illustrate this, we can examine Figure 2, describing two main indicators related to the transportation of goods in Uzbekistan by different modes of transportation. We can see that in terms of cargo transportation, which uses payload mass measured in tons, the dynamics of transportation by railway for the period 2000–2013 are lower than those for transportation by truck.

Figure 2: Transport Mode Choice in Uzbekistan

Dynamics of cargo transportation by transportation mode (tons) | Dynamics of cargo turnover by transportation mode (tons/km)



km = kilometer

Note: Cargo transportation is an indicator that defines the volume of cargo in tons, transferred by means of the transportation of enterprises, the main activity of which is cargo carriage. Cargo turnover is an indicator of the volume of carriage operations of the transport mode taking into account the distance of transportation by tons per kilometer (t/km).

Source: Statistics Committee of the Republic of Uzbekistan (2014).

However, in terms of cargo turnover, which also takes into account the distance of transportation, we can see that the indicator for rail for the majority of the period either surpasses or equals that of truck transportation. This demonstrates the positive role of distance in choosing the option of rail as a mode of transportation.

The last step in supporting the distance argument might be to compare the length of both the railway lines and paved roads actually available in Uzbekistan to check for the absence of physical constraints on trucks transporting cargo over long distances. Table 2 clearly demonstrates that in 2013 the length of paved roads available (42,654 km) was 10 times greater than that of railway lines (4,187 km), which shows that the higher cargo turnover indicator for railway transportation is not due to constraints on truck transportation, but rather the conventional nature of transportation mode choice consistent with previous empirical evidence.

Table 2: Transport Modes in Uzbekistan, 2005–2013

Transportation Mode	Railway lines		Main Pipelines	Highways	
Year	Total length (km)	Railway lines with electrification (km)	Total length (km)	Total length (km)	Roads of international importance (km)
2005	4,014	593.9	13,452	42,530	3,626
2006	4,005	593.9	13,144	42,539	3,626
2007	4,230	589.0	13,402	42,558	3,626
2008	4,230	589.0	13,716	42,557	3,626
2009	4,230	589.0	13,716	42,537	3,626
2010	4,227	674.3	14,280	42,654	3,979
2011	4,258	727.4	14,280	42,654	3,979
2012	4,192	702.0	14,325	42,654	3,979
2013	4,187	698.2	14,342	42,654	3,979

km = kilometer.

Source: State Statistics Committee of the Republic of Uzbekistan (2014).

Proceeding from the above, this study examines three possible contexts for the evaluation of the impacts of infrastructure: regional effects, which capture the direct effect of infrastructure on the regions in which it is located; spillover effects, which include neighboring affected regions; connectivity effects, which examine the variations in outcome variables in the regions located at the far ends (terminal stations) of the within-country railway system and hub region (central Steiner point) after the introduction of a new railway line.

4.2 Assumptions about the Timing of the Impact of Infrastructure Provision

With regard to evaluating the timing of the impact, we examine three perspectives: launch effects, anticipation effects, and postponed effects.

The launch effect captures the impact created by infrastructure provision immediately after the commissioning of the railway line. Although the TBK railway line commenced operation in August 2007, the vital components of the railway line, in particular two of the five bridges, were constructed only by the end of 2008. Taking this into account, we set the launch period after 2008, covering the period 2009–2012. Within the post-railway or post-treatment period, we differentiate between short-, mid- and long-term effects, covering 2, 3, and 4 years, respectively. Therefore, our regression framework takes the following form:

$$\Delta Y_{it} = \alpha_i + \varphi_t + X'_{it}\beta + \delta_{\tau=0}\left(D_{gt\{2010:2009\}}\right) + \epsilon_{it}$$

$$\Delta Y_{it} = \alpha_i + \varphi_t + X'_{it}\beta + \delta_{\tau=0}\left(D_{gt\{2011:2009\}}\right) + \epsilon_{it}$$

$$\Delta Y_{it} = \alpha_i + \varphi_t + X'_{it}\beta + \delta_{\tau=0}\left(D_{gt\{2012:2009\}}\right) + \epsilon_{it}$$

On the other hand, one might conclude that such treatment is endogenous and opt for a technical solution by choosing a set of instrumental variables. A major stream of literature queries the feasibility of treating infrastructure provision as a randomized trial, given the evidence that the design process indicates possible effects of economically significant provincial regions on railway planning, raising the question of the endogeneity of the treatment itself.

However, the disjointed railway system in the former-Soviet Union countries compromised levels of economic outcomes in connected regions. The initiation of railway construction by Uzbekistan's central government provides a more favorable environment for addressing the issue of reverse causality and the treatment of endogeneity assuming the randomized assignment of rail routing, which is not induced by the performance of local economies or the policies of local administrations. Furthermore, the influence of unobserved variables, such as the political preferences of the community on both the dependent variable and the intervention itself, can easily be dealt with using panel data (see Elbers and Gunning [2013]), which we exploit in framing our study. Understanding the background to the project examined and its relation to the outcome variables might help to differentiate between the presence of endogeneity and the occurrence of anticipation (ex ante) effects, both of which might be revealed as pre-trends in the scope of the analysis. Understanding that expectations may induce some effect on the outcome variable of interest can contribute to a more comprehensive assessment of the projects under consideration.

Anticipation of the infrastructure project might induce positive economic effects, serving as positive shocks to the investment climate or trade terms. For example, Rose and Spiegel (2011) found that even unsuccessful bids made to host the Olympics had a positive impact on a country's exports, concluding that what matters is the signal countries transmit to international markets when bidding to host the Olympics.

With a lesser degree of information asymmetry, the existence of forward-looking agents whose responses anticipate future treatment might give rise to the need to evaluate those impacts that cause changes in outcomes before the implementation of a new program or the provision of a railway connection. Malani and Reif (2011) provide a survey of the literature and lists the frameworks for the paradigm of a policy effect that occurs at time t+k, but that is announced or adopted during an earlier period, at time t.

After incorporating 1 and 2 years of anticipation effects into the post-treatment period, the regression framework including anticipation effects for full short-, mid- and long-term impact evaluation takes the following form:

With 1 year of anticipation: $\Delta Y_{it} = \alpha_i + \varphi_t + X'_{it}\beta + \delta_{\tau=-1}\big(D_{gt\{2010:2008\}}\big) + \epsilon_{\ it}$

$$\Delta Y_{it} = \alpha_i + \varphi_t + X'_{it}\beta + \delta_{\tau=-1}\big(D_{gt\{2011:2008\}}\big) + \epsilon_{\ it}$$

$$\Delta Y_{it} = \alpha_i + \varphi_t + X'_{it}\beta + \delta_{\tau=-1}\big(D_{gt\{2012:2008\}}\big) + \epsilon_{\ it}$$

With 2 years of anticipation: $\Delta Y_{it} = \alpha_i + \varphi_t + X'_{it}\beta + \delta_{\tau=-2}\big(D_{gt\{2010:2007\}}\big) + \epsilon_{\ it}$

$$\Delta Y_{it} = \alpha_i + \varphi_t + X'_{it}\beta + \delta_{\tau=-2}\big(D_{gt\{2011:2007\}}\big) + \epsilon_{\ it}$$

$$\Delta Y_{it} = \alpha_i + \varphi_t + X'_{it}\beta + \delta_{\tau=-2}\big(D_{gt\{2012:2007\}}\big) + \epsilon_{\ it}$$

When considering the analysis of anticipation effects, one might naturally also posit the possibility of postponed effects from infrastructure provision. In other words, businesses might respond to the launch of a new railway line with some lag. Similar to the context with the inclusion of anticipation effects in the full impact evaluation, we can make the same adjustment to incorporate postponed effects with 1 and 2 years of lag:

$$\Delta Y_{it} = \alpha_g + \varphi_t + X'_{it}\beta + \delta_{\tau=1}\big(D_{gt\{2012:2010\}}\big) + \epsilon_{\ it}$$

$$\Delta Y_{it} = \alpha_g + \varphi_t + X'_{it}\beta + \delta_{\tau=2}\big(D_{gt\{2012:2011\}}\big) + \epsilon_{\ it}$$

Finally, the variables of interest in our analysis, besides regional GDP, are the sector components. Sectoral studies of infrastructure investment (Pereira and Andraz 2003, 2007; Yoshino and Nakahigashi 2000) indicate that the impact of infrastructure investment might have differential effects on economic sectors. Our scope of analysis covers agricultural value added, industrial value added, and services value added.

5. DATA

We created a unique panel data set containing information on the economic characteristics of regions in Uzbekistan via a compilation of yearly and quarterly data from the State Statistics Committee of the Republic of Uzbekistan (2014), and yearly reports from the Ministry of Finance of Uzbekistan (2014), available for the period 2005–2012. Descriptive statistics for all outcome variables are provided in Tables 3–5, for the affected regions.

Regional GDP, which serves as the outcome variable in our analysis, is defined as the part of Uzbekistan's GDP produced in the territory of the corresponding region—the first-order administrative division. These include 12 regions, the autonomous republic of Karakalpakstan, and the city of Tashkent.

In addition to regional GDP, the State Statistics Committee of the Republic of Uzbekistan (2014) provides consistent data on growth rates for its three essential components: agricultural output, industrial output, and services.

Table 3: Summary Statistics for Outcome Variables for the Regional Effects Context

Regional Effects Context

Affected Administrative Divisions:
Kashkadarya and Surkhandarya regions

$D_{i=regional}$ =0

Variable: Growth rate (%)	**Number of observations**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Regional GDP	96	8.5	2.8	0.6	18.6
Industrial output	96	11.5	8.4	-5.3	36.8
Agricultural output	96	5.7	2.8	0	13.7
Services	96	17.6	5.9	4.8	35.4

$D_{i=regional}$ =1

Variable: Growth rate (%)	**Number of observations**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Regional GDP	16	7.4	2.5	3.1	11.7
Industrial output	16	8.6	6.4	-2.4	18.9
Agricultural output	16	5.3	3.3	0.8	12.8
Services	16	18.0	8.0	7.4	34.1

GDP = gross domestic product.

Source: State Statistics Committee of the Republic of Uzbekistan (2014).

The notion of agricultural output in the context of our analysis consists of the combination of subsectors that constitute agricultural production (plant growing and animal husbandry) according to International Standards of Industrial Classification (ISIC): forestry, fishery, and hunting.

Similarly, industrial output is considered to be the sum of data on the volume of products of individual industrial enterprises This stock of output is defined by the

Statistics Committee of Uzbekistan as the cost of all final products produced and the cost of semifinal products realized by enterprises during the period under review, as well as the cost of production-related works carried out by the enterprises during the same period. According to ISIC, this output includes such sectors as mining, manufacturing, and construction, as well as the output of enterprises that supply electricity, water, and gas. Also, the social and economic accounts of Uzbekistan classify the outputs of mining and manufacturing industries as industrial output.

Services corresponds to the real growth rate of the total monetary amount of rendered services, such as communications, transport, retail, wholesale, hotel and restaurant business, and warehouses. This indicator also includes enterprises and institutions that render financial, insurance, real estate-related, business, community, and social and private services (education, health care).

Table 4: Summary Statistics for Outcome Variables for the Spillover Effects Context

Spillover Effects Context

Affected Administrative Divisions:
Bukhara, Kashkadarya, Samarkand, and Surkhandarya regions

$D_{i=spillover}=0$

Variable: Growth rate (%)	**Number of observations**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Regional GDP	80	8.4	2.9	0.6	18.6
Industrial output	80	11.5	8.7	-5.3	36.8
Agricultural output	80	5.6	2.9	0	13.7
Services	80	17.6	5.8	7	35.4

$D_{i=spillover}=1$

Variable: Growth rate (%)	**Number of observations**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Regional GDP	32	8.0	2.4	3.1	13.6
Industrial output	32	10.2	6.9	-2.4	24.6
Agricultural output	32	6.0	2.9	0.8	12.8
Services	32	17.6	7.3	4.8	34.1

GDP = gross domestic product.

Source: State Statistics Committee of the Republic of Uzbekistan (2014).

Turning to the explanatory variables in our specification, the report also provides highly detailed information on the dynamics of different types of investment shares in the regions of Uzbekistan. Investments are divided into public sector investment, consisting of investment made by the state, and private sector investment, encompassing investment by the public, banks, and foreign companies. The State Statistics Committee of Uzbekistan defines foreign direct investment as a net inflow of investment to acquire a lasting management interest with 10% or more of voting stock in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, and short-term and long-term capital.

Yearly time series variables indicating government expenditures on health care, education, and R&D are derived from yearly reports by the Ministry of Finance of the Republic of Uzbekistan (2014).

Table 5: Summary Statistics for Outcome Variables for the Connectivity Effects Context

Connectivity Effects Context

Affected Administrative Divisions:
Samarkand, Surkhandarya, and Tashkent regions;
the Republic of Karakalpakstan

$D_{i=connectivity} = 0$

Variable: **Growth rate** (%)	**Number of observations**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Regional GDP	80	8.3	2.9	0.6	18.6
Industrial output	80	11.0	8.8	-5.3	36.8
Agricultural output	80	5.6	2.9	0	13.7
Services	80	17.5	6.7	4.8	35.4

$D_{i=connectivity} = 1$

Variable: **Growth rate** (%)	**Number of observations**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Regional GDP	32	8.2	2.3	3	13.6
Industrial output	32	11.5	6.7	0.3	28.6
Agricultural output	32	6.0	3.0	0.1	12.8
Services	32	17.8	5.1	11.1	33.1

GDP = gross domestic product.

Source: State Statistics Committee of the Republic of Uzbekistan (2014).

6. ESTIMATION RESULTS

First, we estimate equation (4) in a specification including only the percentage of the labor force and total investment as the explanatory variables, together with an interaction term that captures the difference-in-difference coefficient. In their influential paper, Mankiw, Romer, and Weil (1992) found that these factors together with human capital explained more than 80% of variation in the GDP growth rate. Consequently, our baseline specification is augmented by including government spending on education, health care, and R&D. However, before doing so, we partial out the impacts attributed to dynamics in tax revenue from mineral resources and favorable trade terms on a region's growth rate (see Barro [1996]). Finally, in an attempt to account for potential nonlinearities where the impact of government expenditure as part of fiscal stimulus might cause an ambivalent effect on the economy (Bruckner and Tuladhar 2010), the quadratic term of the state investment share as well as its reciprocal is added to the right-hand side of our equation.

Table 6 presents the estimation results for nine versions of equation (4). The interaction term reported in the table, $D_{i=connectivity} \times D_{t=2012–2009}$, focuses on the comparison of the trajectory for the counter-factual scenario without infrastructure provision to the actual performance of the regions after launching the new railway line in the frame of connectivity effects (for the Republic of Karakalpakstan, and the Samarkand, Surkhandarya, and Tashkent regions) for the 4-year from 2009 to 2012, defined as "long-term" in the scope of our analysis. Similarly, the scope of regional effects focuses on the Surkhandarya and Kashkadarya regions, the actual geographical location of the newly provided railway line, whereas the hypothesis of spillover effects presupposes looking at the these two regions together with the adjacent Bukhara and Samarkand regions.

Regression 1 exhibits the simplest specification form and has a difference-in-difference coefficient of 1.43, meaning that the introduction of the railway connection in the Surkhandarya and Kashkadarya regions in the southern part of Uzbekistan caused around 1.43% higher regional GDP growth in the four regions located at the far ends of the railway system compared to the counter-factual scenario of the growth trend.

However, regression 1 does not consider year-specific conditions, which might put upward pressure on the state of the economy in the regions, although it does account for region-specific idiosyncratic characteristics. Regression 2 solves this problem by controlling for time-specific characteristics, which increases the coefficient on the interaction term to approximately 1.90. Subsequent F-statistics testing the exclusion of the groups of variables confirm the strong significance of time-specific effects in regional GDP growth as represented in the column for regression 2 in Table 6. This might suggest that year-specific effects inform changes in overall legislation or that the general business climate in the transition economy might have significant relevance for the economic performance of regions. Simultaneously, this also gives rise to the need to consider the issues of heteroscedasticity and autocorrelation.

Regression 3, following discussions on potential autocorrelation within a region (Bertrand, Duflo, and Mullainathan 2004) and employs HAC standard errors, which allow for heteroscedasticity and arbitrary autocorrelation within entities but treat the errors as uncorrelated across regions. This perspective in our analysis is consistent with the fixed effects regression assumption of independent and identical distribution across entities. As a result, although regression 3 reports difference-in-difference coefficients that are identical in magnitude to those of regression 2, the corresponding t-values do vary, being 2.39 for regression 2 and 3.52 for regression 3.

The next step of the analysis, in regressions 4 and 5, examines the hypothesis of the so-called “resource curse” as well as changes in external trade, for which, depending on the institutional quality of the country, the response of economic growth to changes in terms of trade might be of a dubious nature (see Fosu [2011]). To compute an unbiased coefficient of the interaction term in our regression analysis, we partial out the impacts of total tax revenues from mineral resources and volatility in the terms of trade, calculated for each region in the form of the export–import ratio, following Barro (1996). The role the added variables play in our augmented specification with respect to the difference-in-difference coefficient confirms our expectations: in regression 4, both the size of the coefficient of interest and its significance is lower than in regression 3, and controlling for terms of trade in regression 5 further decreases this characteristic of the interaction term. The magnitude of the difference-in-difference coefficient decreases from around 1.90 to 1.73 in regression 4 and to 1.67 in regression 5. However, in both regressions controlling for tax from mineral resources and terms of trade, we obtain a statistically significant impact from the introduction of the railway connection as observed by the economic performance of the regions located at the far ends of the railway system.

The non-hierarchal stepwise inclusion of additional variables provides us with four more specifications of estimation equations, with regression 9 considered to be the representative regression in the scope of our analysis.[5] Thus, differentiating the shares of investment in total investment by financing source reverses the trend of obtaining lower coefficients on the interaction term, these being 1.82 and 1.83 in regressions 6 and 7, but provides lower t-values in comparison to the specifications in regressions 4 and 5. Concerns about non-linearity and the dependency of investments by the state on the level of government implementation (Bruckner and Tuladhar 2010) are addressed in regressions 8 and 9 by including the squared term of the variable for the share of public investment as well as its reciprocal. These augmentations further increase the impact of the interaction term on regional GDP growth, pushing the sizes of the coefficient to 2.05 and around 2.07 in regressions 8 and 9, respectively. In addition, we find that these point estimations become more significant in comparison to those in regressions 6 and 7, with t-values in regressions 8 and 9 being equal to 3.12 and 3.04, respectively.

[5] This follows from the property of conditional variance which states that $E[Var(y|x)] \geq E[Var(y|x,z)]$ (see Wooldridge [2010]). If the mean squared error (*MSE*) for function $m(.)$ is defined as *MSE* $(y;m) \equiv E\left[\left(y-m(x)\right)^2\right]$, then $MSE\ [y;E(y|x)] \geq MSE[y;E(y|x,z)]$.

Table 6: Regional GDP Growth Rate and Railway Connection: Estimation Output for the Long-Term Connectivity Effects Context

	Regression 1	Regression 2	Regression 3	Regression 4	Regression 5	Regression 6	Regression 7	Regression 8	Regression 9
Time period	2005–2012	2005–2012	2005–2012	2005–2012	2005–2012	2005–2012	2005–2012	2005–2012	2005–2012
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered standard errors	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant term	-12.654136	10.964116	10.964116	13.471501	14.565685	-39.091506	-39.56261	-31.800912	-34.853143
	[-1.4]	[0.65]	[0.91]	[1.17]	[1.24]	[-0.97]	[-0.97]	[-0.79]	[-0.84]
$D_{i=connectivity} \times D_{t=\{2012:2009\}}$	1.4271899*	1.8967071**	1.8967071***	1.7323495***	1.6731193***	1.8218219**	1.8335153**	2.0507275***	2.068127***
	[1.78]	[2.39]	[3.52]	[3.13]	[3.07]	[2.39]	[2.22]	[3.12]	[3.04]
Percentage of working population	.3604556**	-0.07947589	-0.07947589	-0.06406068	-0.07312964	-0.02115908	-0.04695342	-0.01233161	0.00520423
	[2.26]	[-0.26]	[-0.37]	[-0.3]	[-0.34]	[-0.07]	[-0.14]	[-0.04]	[0.02]
Total investment	-0.00013171	-0.00041919	-0.00041919	-0.00039944	-0.00031503	0.00090568	0.00095911	0.00120291	0.0011378
	[-0.25]	[-0.71]	[-0.92]	[-0.87]	[-0.59]	[1.3]	[1.38]	[1.61]	[1.48]
Tax revenue from mineral resources				-0.00950594	-0.01065215	.0502165*	0.04553295	0.04327416	0.04317435
				[-1.64]	[-1.63]	[2.04]	[1.71]	[1.71]	[1.67]
Terms of trade (ratio of exports and imports)					-0.05232616	-0.08250415	-0.07954066	-0.06465478	-0.05148601
					[-0.89]	[-1.23]	[-1.22]	[-1.09]	[-0.81]
Investment by population						.05208357*	.04953587*	.05687527**	.07035797**
						[2.05]	[1.94]	[2.31]	[2.21]
Investment from bank loans						0.05388027	0.06725393	0.10333667	0.12192484
						[0.41]	[0.48]	[0.79]	[0.89]
Investment by foreign investors						0.03720977	0.03595292	.0519062*	.06322048**
						[1.14]	[1.15]	[1.84]	[2.58]
Investment from bank loans x treat_dummy						0.16417674	0.15753075	0.1353114	0.12833878
						[1.05]	[0.94]	[0.89]	[0.81]
Government expenditure: education						0.03482988	0.03793717	0.03090266	0.0301538
						[0.73]	[0.79]	[0.64]	[0.62]
Government expenditure: health care						-0.02501876	-0.02202106	-0.02919047	-0.02553963
						[-0.35]	[-0.29]	[-0.37]	[-0.33]
Government expenditure: R&D						-2.2957532	-2.450452	-1.869495	-1.9240766
						[-1.38]	[-1.5]	[-1.23]	[-1.23]
Initial services per capita						-0.00067578	-0.00116788	-0.00086865	-0.00092395
						[-1.03]	[-1.24]	[-1.01]	[-1.01]
Investment by state							-0.03375464	-0.03021992	-0.02946592
							[-1.5]	[-1.23]	[-1.16]
Investment by state_reciprocal								-3.761641**	-3.4260914*
								[-2.54]	[-1.96]
Investment by state^2									0.00126066
									[0.68]
F-statistics and p-values testing exclusion of group of variables									
Time effects = 0		4.18 (0.0005)	13.72 (0.0000)	16.63 (0.0000)	14.95(0.0000)	17.83(0.0000)	14.79(0.0000)	16.55(0.0000)	19.09(0.0000)
Investment from state budget = Investment from population							9.49(0.0088)	11.97(0.0042)	11.3(0.0051)
Investment from state budget = Investment from bank loans and others							0.51(0.4895)	0.97(0.3426)	1.17(0.2984)
Investment from state budget = Investments by foreign investors							2.05(0.1758)	3.35(0.0903)	4.92(0.0449)
Investment bank loans and other = Investments by foreign investors						0.01(0.9069)	0.05(0.8339)	0.15(0.7022)	0.19(0.6741)
Number of observations	112	112	112	112	112	112	112	112	112
R^2	0.14558409	0.35879783	0.35879783	0.36092367	0.36234278	0.44656874	0.45200681	0.46666631	0.47036421

GDP = gross domestic product, R&D = research and development.

Note: t-values are in brackets. The t-values measure how many standard errors the coefficient is away from zero. p-values are shown in parentheses. Significance levels: * p<.1, ** p<.05, *** p<.01.

Source: Authors' calculations.

Regarding the nuisance parameters, we observe that once we control for nonlinearities, based on the nature of government investments reported in the literature, the shares of investment by the population and foreign investors are identified as significant factors influencing regional economic performance. These might be related to the absence of the agency problem and information asymmetry compared to the case of public investment. In this respect, Afonso and Aubyn (2009), by estimating vector autoregressions for 14 European Union countries, as well as Canada, Japan, and the United States, found that public investment had a contractionary effect on output in five cases between 1960 and 2005. This was namely for GDP growth rates in Belgium, Canada, Ireland, the Netherlands, and the United Kingdom, with positive public investment impulses leading to a decline in private investment, suggesting potential crowding out effects. Similar to our results, Afonso and Aubyn (2009) report that private investment impulses were always expansionary in GDP terms and the effects were prevailingly higher in terms of statistical significance.

The interrogation of assumptions and frameworks for regional scope and timing provides a wide range of combinations of specifications to estimate.

Given our set of assumptions concerning geographical location, timing, and the timeframe of the impact, our analysis comprises the following steps: first, we estimate all 1,188 versions of the regressions[6] arising from the aforementioned combinations; then, in Tables 7–10 we report the coefficients of the interaction term, corresponding to the specification adopted for regression 9 in Table 6. Each of these four subsequent tables contains 33 coefficients placed in accordance with the chosen assumptions on timing and geographical location, varying by the dependent variable of interest. Thus, our estimate of 2.06 with a t-value of 3.04 is found in Table 7, which reports the estimation coefficients of difference in difference with the variable of interest set as the regional GDP growth rate. The coefficient is displayed in the corresponding cell at the juxtaposition of the row for long-term launch effects and the column for connectivity effects (see shaded area in Table 7). Similarly, Tables 8, 9, and 10 report coefficients of the interaction term linked to the growth rate of the agricultural sector, the industrial sector, and the services sector, respectively.

Table 7 presents the estimation results of the difference-in-difference coefficient for the regional GDP outcome variable. The impact of infrastructure provision after launch in terms of connectivity effects demonstrates a positive and significant effect for railway connection. Regions located at the far ends of the railway system seem to be experiencing 2.8%, 2.5%, and 2% higher growth of regional GDP in the short-, mid-, and long-term periods, respectively. This result is consistent with previous empirical studies that reveal a positive role of distance for the use of rail as a transportation mode (Beuthe et al. 2000; Jiang, Johnson, and Calzada 1999; Wang et al. 2013). The regional effect of the railway connection seems to be positive for the short- and mid-term perspectives considered in this study, being around 0.4% and 0.7%, respectively.

[6] The 1,188 versions are derived as follows: 4 dependent variables {GDP growth rate, agricultural valued added, industrial value added, services value added} x 3 geographical combinations {connectivity, regional, spillover} x 11 assumptions about timing {launching effects: short-, mid-, long-term; anticipation effects: 1 year and 2 years, short-, mid-, long-term; postponed effects: 1-year and 2-year lags} x 9 specifications of regressions.

Table 7: Difference-in-Difference Coefficients with the GDP Outcome Variable

			Connectivity Effect	Regional Effect	Spillover Effect
		D_i / D_t	$D_{g = connectivity}$	$D_{g = regional}$	$D_{g = spillover}$
Launch Effects					
	Short-term	$D_{t=2010:2009}$	2.83***[4.48]	0.70[0.45]	1.33[1.14]
	Mid-term	$D_{t=2011:2009}$	2.5***[6.88]	0.36[0.29]	1.27[1.46]
	Long-term	$D_{t=2012:2009}$	2.06***[3.04]	-0.42[-0.29]	2.29**[2.94]
1 year	**Anticipation Effects**				
	Short-term	$D_{t=2010:2008}$	0.19[0.33]	0.85[1.75]	-0.18[-0.20]
	Mid-term	$D_{t=2011:2008}$	0.31[0.51]	0.64[1.30]	-0.02[-0.03]
	Long-term	$D_{t=2012:2008}$	0.07[0.13]	-0.006[-0.01]	0.50[0.67]
	Postponed Effects	$D_{t=2012:2010}$	1.76*[1.95]	-1.49[-0.72]	2.58*[2.03]
2 years	**Anticipation Effects**				
	Short-term	$D_{t=2010:2007}$	-1.54[-1.66]	1.42[0.78]	-1.32[-0.92]
	Mid-term	$D_{t=2011:2007}$	0.32[0.44]	0.84[1.42]	0.13[0.13]
	Long-term	$D_{t=2012:2007}$	0.11[0.15]	0.10[0.16]	0.87[1.19]
	Postponed Effects	$D_{t=2012:2011}$	-0.14[-0.20]	-1.71[-1.35]	1.05[1.44]

GDP = gross domestic product.

Note: t-values are in brackets. The t-values measure how many standard errors the coefficient is away from zero. Significance levels: * p<.1, ** p<.05, *** p<.01.

Source: Authors' calculations.

The hypothesis of spillover effects documented in regional-level studies by Pereira and Andraz (2003) for states in the United States and Pereira and Roca-Sagales (2007) for regions of Spain is also found to hold in the case of Uzbekistan—with the assumption of launch effects, the magnitude of the long-term impact is around 2.3%. Finally, the framework of postponed effects, in which we estimate the impact of the railway connection with a 1-year lag, provides differences of approximately 1.8% and 2.58% in the growth rates for connectivity and spillover effects, respectively.

The results for the agricultural sector in relation to connectivity effects provide positive and statistically significant (at the 10% level) coefficients of 2.9% and 2% for the short- and mid-term perspectives, respectively (see Table 8). In the longer term perspective, comprising a 4-year period in terms of launch effects, this coefficient is approximately 1%. A similar perspective in relation to regional and spillover effects provides coefficients of approximately –1.2% and –2% in the case of anticipation effects. A possible explanation could be that the decisions of businesses in the agricultural sector may have been affected by considerations regarding the connection by rail from the region in which the infrastructure was located, and its neighboring regions, to the central part of the country. A similar result is documented by Faber (2014) where the provision of the National Trunk Highway System network in the PRC led to reduced output growth among peripheral regions, rather than diffusing production in space.

Table 8: Difference-in-Difference Coefficients with the Agriculture Outcome Variable

		D_i / D_t	Connectivity Effect $D_{g = connectivity}$	Regional Effect $D_{g = regional}$	Spillover Effect $D_{g = spillover}$
Launch Effects					
	Short-term	$D_{t=2010:2009}$	2.95*[1.91]	1.35[0.70]	0.69[0.53]
	Mid-term	$D_{t=2011:2009}$	2.06*[2.09]	0.14[0.07]	0.43[0.33]
	Long-term	$D_{t=2012:2009}$	0.98[1.48]	-0.68[-0.65]	-0.11[-0.11]
1 year	**Anticipation Effects**				
1 year	Short-term	$D_{t=2010:2008}$	0.66[0.60]	0.35[0.49]	-1.05[-1.29]
1 year	Mid-term	$D_{t=2011:2008}$	0.32[0.35]	-0.39[-0.56]	-1.05[-1.32]
1 year	Long-term	$D_{t=2012:2008}$	-0.56[-0.81]	-1.25*[-1.82]	-1.98**[-2.79]
1 year	**Postponed Effects**	$D_{t=2012:2010}$	-1.11[-0.99]	-0.98[-1.30]	0.28[0.29]
2 years	**Anticipation Effects**				
2 years	Short-term	$D_{t=2010:2007}$	-1.03[-0.85]	-0.26[-0.14]	-1.95[-1.40]
2 years	Mid-term	$D_{t=2011:2007}$	-1.18[-1.41]	-0.20[-0.27]	-0.87[-1.11]
2 years	Long-term	$D_{t=2012:2007}$	-2.48***[-3.79]	-1.16[-0.60]	-1.97[-1.66]
2 years	**Postponed Effects**	$D_{t=2012:2011}$	-1.71[-1.25]	-3.19**[-2.23]	-1.14[-1.07]

Note: t-values are in brackets. The t-values measure how many standard errors the coefficient is away from zero. Significance levels: * p<.1, ** p<.05, *** p<.01.

Source: Authors' calculations.

Table 9 shows the results of the estimation of the difference-in-difference coefficient for when the outcome variable is industrial output. Consistent with the findings of Yoshino and Nakahigashi (2000), which reveal a varying impact of infrastructure over sectors, our estimation results indicate a positive, long-term impact of the railway connection on industrial output after launch, with estimates of approximately 5.2%, 3.1%, and 3.5% for connectivity, regional effects, and spillover effects, respectively. The industrial sector also demonstrates significant and positive short- and mid-term effects in relation to anticipation effects for regional and spillover effects. The coefficients for the short-term anticipation effects are approximately 3.9% and 4% for regional effects and spillover effects, respectively.

The services sector, including services provided in the forms of tourism hospitality and passenger and cargo transportation, indicates a significant and positive coefficient, achieving the highest magnitude among the sectors analyzed (see Table 10). In relation to the launch effects, the short-, mid-, and long-term impacts of the railway connection differentiated the growth rate of the services sector in the regions located at the far ends of the railway system by approximately 7.8%, 6.5%, and 6.9%, respectively. The results for the regional and spillover effects appear to be negative but statistically insignificant in our analysis. Interestingly, the services sector does not seem to react in anticipation of the railway connection, an effect which might be explained by its difference from the industrial sector in terms of its inability to accumulate or store services.

Table 9: Difference-in-Difference Coefficients with the Industry Outcome Variable

			Connectivity Effect	Regional Effect	Spillover Effect
		D_i / D_t	$D_{g = connectivity}$	$D_{g = regional}$	$D_{g = spillover}$
Launch Effects					
	Short-term	$D_{t=2010:2009}$	5.27*[1.94]	3.14[0.68]	2.82[0.99]
	Mid-term	$D_{t=2011:2009}$	4.5[1.61]	2.56[0.80]	2.13[0.83]
	Long-term	$D_{t=2012:2009}$	5.23[1.51]	3.16[0.67]	3.54[0.92]
1 year	**Anticipation Effects**				
	Short-term	$D_{t=2010:2008}$	2.47[1.74]	3.89**[2.60]	4.03**[2.58]
	Mid-term	$D_{t=2011:2008}$	2.53[1.50]	3.69*[2.02]	3.43*[2.02]
	Long-term	$D_{t=2012:2008}$	3.79[1.68]	4.62[1.51]	5.13*[1.85]
	Postponed Effects	$D_{t=2012:2010}$	6.12[1.65]	-0.21[-0.03]	3.92[0.95]
2 years	**Anticipation Effects**				
	Short-term	$D_{t=2010:2007}$	-0.85[-0.25]	4.81[0.71]	4.01[1.07]
	Mid-term	$D_{t=2011:2007}$	3.90*[1.93]	3.68[1.23]	5.21**[2.33]
	Long-term	$D_{t=2012:2007}$	5.83**[2.72]	4.60[1.37]	8.14[2.45]
	Postponed Effects	$D_{t=2012:2011}$	1.61[0.46]	1.15[0.27]	0.61[0.19]

Note: t-values are in brackets. The t-values measure how many standard errors the coefficient is away from zero. Significance levels: * p<.1, ** p<.05, *** p<.01.

Source: Authors' calculations.

Table 10: Difference-in-Difference Coefficients with the Services Outcome Variable

			Connectivity Effect	Regional Effect	Spillover Effect
		D_g / D_t	$D_{g = connectivity}$	$D_{g = regional}$	$D_{g = spillover}$
Launch Effects					
	Short-term	$D_{t=2010:2009}$	7.76***[3.07]	-3.90[-0.53]	0.03[0.01]
	Mid-term	$D_{t=2011:2009}$	6.48**[2.41]	-1.83[-0.22]	0.37[0.09]
	Long-term	$D_{t=2012:2009}$	6.92***[2.72]	-1.45[-0.17]	3.08[0.71]
1 year	**Anticipation Effects**				
	Short-term	$D_{t=2010:2008}$	4.20[1.67]	-3.58[-0.70]	-2.95[-0.83]
	Mid-term	$D_{t=2011:2008}$	4.07[1.39]	-2.31[-0.35]	-2.34[-0.59]
	Long-term	$D_{t=2012:2008}$	5.41[1.69]	-2.17[-0.31]	-0.85[-0.20]
	Postponed Effects	$D_{t=2012:2010}$	0.88[0.29]	-0.02[-0.01]	3.05[0.80]
2 years	**Anticipation Effects**				
	Short-term	$D_{t=2010:2007}$	4.70**[2.19]	0.40[0.10]	-3.23[-0.82]
	Mid-term	$D_{t=2011:2007}$	4.62[1.72]	-0.24[-0.05]	-2.63[-0.78]
	Long-term	$D_{t=2012:2007}$	6.61**[2.27]	0.38[0.07]	-0.90[-0.26]
	Postponed Effects	$D_{t=2012:2011}$	1.33[0.47]	3.03[0.57]	4.02[1.53]

Note: t-values are in brackets. The t-values measure how many standard errors the coefficient is away from zero. Significance levels: * p<.1, ** p<.05, *** p<.01.

Source: Authors' calculations.

7. CONCLUSIONS

In this study, we examine the impact of a railway connection in the southern part of Uzbekistan in an attempt to determine the nature of change in the economic performance of regions affected by the newly provided infrastructure. The empirical evidence derived from difference-in-difference estimation for regional, spillover, and connectivity effects has focused on the regional GDP growth rate, agricultural value added, industrial value added, and services value added.

Our underlying hypothesis assumed that changes in the growth rates of economic outcomes at the regional level in treated regions would be induced only through the newly built railway connection, conditional on regions' individual (time-invariant) effects, investment, government spending, natural resource extraction, external trade turnover, and evolving economic characteristics (year effects). Having investigated the impact of the railway connection on economic outcome variables in the regions where the infrastructure is located as well as neighboring regions, and defining these effects as regional effects and spillover effects, we estimated the connectivity effects, which place emphasis on the observation of variation in the economic performance of the regions located at the far ends of the within-country railway system. Our empirical results suggest that the TBK railway line encouraged an increase of around 2% in regional GDP growth in regions located at the far ends of the within-country railway system. The regional effects from the railway connection seem to be positive but of smaller magnitude in the short- and mid-term perspectives analyzed, being around 0.4% and 0.7%, respectively.

In the spectrum of economic sectors, the positive effect reflected in regional GDP seems to be driven by an increase in industrial output and aggregate services, with estimates of approximately 5% and 7%, respectively. The effect on agricultural output is moderate in comparison to other sectors, constituting around 1% for connectivity effects, which is consistent with previous literature on the impacts of public capital.

In particular, as the introduction of the railway line in one part of the country has caused positive changes in the economic performance in other parts, it is important to determine which group of regions has experienced the greatest increase in economic performance based on the provision of the infrastructure within the limited period of time. The findings of the study suggest that the railway connection has not only generated a positive impact in the region in which it is located, but has also contributed to economic growth in the most geographically distant parts of the country. At the same time, the positive and significant changes in the industrial output of the directly affected and neighboring regions predominantly occurred during the design and construction period in anticipation of the railway connection.

However, to sound a note of caution, although our research framework was formulated to constitute a comprehensive evaluation obtained by the juxtaposition of aspects of location, time, and sector, the results of the empirical study are open for discussion and are far from being final.

Finally, it should be noted that although the current study provides empirical results related to the impact of infrastructure provision using regional data for Uzbekistan, the nature of effects of the infrastructure provision might be mirrored throughout the transition economies of Central Asia, as well as in other developing countries of Asia that might share a commonality of processes accompanying emerging markets.

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