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Public Infrastructure and Regional growth: Evidence from Turkey

Zeynep Elburz[1]
Dokuz Eylul University, Department of City and Regional Planning Izmir, Turkey

Peter Nijkamp[2]
Tinbergen Institute, Amsterdam, The Netherlands
A. Mickiewicz University, Poznan, Poland

Eric Pels[3]
VU University, Department of Spatial Economics, Amsterdam, The Netherlands

The aim of this study is to examine the effects of public transportation infrastructure investments on regional economic growth in Turkish NUTS 2 regions between 2004 and 2011. To offer an advanced statistical analysis, we employ an augmented production function model for measuring the effects of different types of transportation infrastructure on regional output. We use specifically ordinary least squares (OLS), fixed effects, two-stage least squares (2SLS) and Hausman-Taylor IV estimation methods with both cross-section and panel data. Our results show that road and motorway infrastructure have strongly significant positive effects on regional output in all our estimations. Land infrastructure is found to play a very important role in regional economic performance in Turkey, while, somewhat surprisingly, air infrastructure has no significant impact on regional GVA, which clearly suggests the existence of different types of transportation infrastructure in the Turkish regions. Also, the high growth elasticity of land infrastructure in the Turkish regions indicates that Turkey is currently still suffering from an inadequate transport infrastructure.

Keywords: *regional growth, transport infrastructure, turkey*

1. Introduction

The economic effects of transport infrastructure on regional-economic growth have attracted a great deal of attention from both policy makers and researchers since the pioneering studies of Aschauer (1989, 1990). The global economic crisis in 2008 and scientific improvements in the methodology to analyze transport infrastructure have lately led this interest to grow even more. Even though there is a widely held in a positive link between transport infrastructure and regional-economic performance, the impacts of transportation infrastructure on the regional economy are still ambiguous because of significant differences in the results of empirical studies. From a policy-makers` point of view, the provision of public infrastructure, which tends to

[1] Dokuz Eylul University Tinaztepe Campus, No: 209, 35160 Buca Izmir, Turkey T: +90 232 301 84 37 E: zeynep.elburz@deu.edu.tr

[2] Tinbergen Institute Gustav Mahlerplein 117, Amsterdam; A. Mickiewicz University, Wieniawskiego 1, 61-712, Poznan, Poland T: +31 65 26 92490 E: pnijkamp1@gmail.com

[3] VU University, Department of Spatial Economics, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands T: +31 20 59 82090 E: a.j.h.pels@vu.nl

generate positive externalities and to boost a productivity rise of firms (Pereira and Andraz, 2010), is an important policy tool for promoting regional growth and reducing regional disparities. For this reason-like most developed and developing countries- Turkey has since the 1960s invested in transportation infrastructure in its less-developed regions in order to diminish regional-economic disparities (Karadağ et al. 2004). The first Development Plan (1963), prepared by the State Planning Organization (SPO), highlights the regional development disparities between Eastern and Western regions in Turkey, and clearly shows how important it is to allocate infrastructure investments in the least developed regions in order to ensure a balanced economic growth in the long run (SPO, 1963). After more than four decades, it is currently recognized that the regional disparities are still remaining, so that improving transport infrastructure in Turkey is still one of the main development strategies according to the 9th and 10th Development Plan (SPO, 2006; Ministry of Development, 2013). To accomplish the economic development goals, 26.3 per cent of the total public investment was assigned to transportation and communication infrastructure investments between 2000 and 2011. This ratio is expected to rise even to 34% in the 2014-2018 period according to the latest Development Plan (Ministry of Development, 2013). The First National Regional Development Strategy (Ministry of Development, 2015), which defines a strengthening of the transportation network and a rise in accessibility as one of the prominent regional development goals, clearly points at connecting economic centers (e.g. İstanbul, Ankara, İzmir, Adana, Mersin) to the rest of the country in view of the trade potentials of these centers.

To the best of our knowledge, this study is the first attempt to measure the economic effects of different types of public transport infrastructure with a broad scope on endogeneity issues using panel data. While most of the empirical studies try to solve the classical causality problem between output and transport infrastructure by using lagged variables (see, e.g. Chen and Haynes, 2013), or, more recently, historical instrumented variables (see, e.g. Möller and Zierer, 2014; Garcia-Lopez et al., 2013), we prefer to employ geographical instruments, viz. the variables elevation and share of arable land in the total surface area of the regions. Furthermore, we estimate the effects of a disaggregated transport infrastructure stock, e.g. road, motorway, railway, air transport, and telecommunication infrastructure, with a Hausman-Taylor IV estimator and panel data to control for the first time in the literature endogeneity. Also, considering the massive amount of investments in transport infrastructure in Turkey, we believe that it is critical to investigate the impacts of these investments on regional economic performance in a fast-growing economy.

The findings indicate that transportation infrastructure- and especially land infrastructure- has a significant positive impact on regional output, which can be explained from the currently inadequate stock of transport infrastructure in the Turkish regions. On the other hand, air infrastructure appears to have on yet no significant effect on regional output, despite a remarkable growth in the Turkish aviation sector over the past decade.

The remaining part of the paper is organized as follows. Section 2 reviews briefly the literature which uses a production function model to estimate the effects of different types of transportation infrastructures. Next Section 3 provides an overview of the methodology and data, while Section 4 presents the results of the econometric modeling analyses. Finally, Section 5 offers a conclusion from our research, suggesting also new pathways for the futures.

2. Literature review

The literature on the impacts of transport infrastructure on economic output has grown exponentially since the seminal work of Aschauer (1989). Aschauer (1989) employs time series data for the USA to estimate the elasticity of public capital stock by means of a production function approach. He finds that core infrastructure is the biggest explanatory variable for the growth of productivity between 1949 and 1985. Munnell (1990) examines the impact of public capital on output at the state level for the USA between 1970 and 1986. She finds that the elasticity of public capital is equal to 0.15, which is smaller than Aschauer`s (1989) findings for national data. Subsequently, Duffy-Deno (1991) evaluates the effects of public infrastructure on the manufacturing sector, and concludes that public capital- and especially transport infrastructure- plays an important role in the composition of a region`s manufacturing sector. Garcia-Mila and McGuire (1992) reach similar results to those of Aschauer (1989), by estimating the impacts of highway infrastructure for 48 states from 1969 to 1983 (see Table 1). On the other hand, many researchers criticize Aschauer and Munnell for not taking into account the causality and the non-stationarity problem of the infrastructure and output data1. In his study, Eisner (1991) questions the cause-effect relationship of public infrastructure and output in Munnell's work. Using instrumental variables, as in Holtz-Eakin and Schwartz (1995) and Percoco (2004), has become a popular and well-known approach to overcome the causality problems (Bröcker and Rietveld, 2009). By using instrumental variables, Evans and Karras (1994) find even evidence of negative effects of highway infrastructure on 48 US states between 1970 and 1986.

More recently, the interest of the research on the impact of transportation infrastructure has shifted to spillover effects, mostly due to the development of spatial econometric models (Cohen, 2010). For example, Jiwattanakulpaisarn et al. (2009) examine states in the US on highway infrastructure and employment relationships between 1984 and 1997, using spatial models. They find evidence of the existence of positive spillovers of the major highways to neighboring states. Tong et al. (2013) employ a spatial Durbin panel model for 44 states in the US with four different spatial weight matrices. Positive and significant spillover effects of the transportation infrastructure showed up only under a second order queen contiguity weight matrix. Yu et al. (2013) investigate spatial spillover effects of transportation infrastructure in Chinese regions between 1978 and 2009. They find both positive and negative spillover effects for different regions and different time periods. For the case of EU regions, Del Bo and Florio (2012) study the role of infrastructure with a spatial Durbin model and reveal negative spatial spillovers to other regions. Moreover, Crescenzi and Rodríguez-Pose (2012) underline a need for re-consideration of the possible spillover effects of the transport infrastructure investment on regional growth based on panel data analysis results for 120 European regions.

The heterogeneity of the empirical results in the infrastructure and output literature has led researchers to investigate the reasons for the sharp differences between different studies. Elburz et al. (2017) synthesize the literature on the effects of transportation infrastructure on regional economic growth by using a statistical meta-analysis. Their results indicate that study characteristics such as research methodology, type of infrastructure, measurement of infrastructure, geographical scope, country coverage, and research period, have an important impact on the sign of the effects on economic growth. According to their findings, the probability of reaching strongly significant positive effects is higher when the empirical studies investigate the effects of telecommunication or land infrastructure. In another meta-analysis, Melo et al. (2013) analyze the productivity and transport infrastructure link, and suggest that road infrastructure has greater effects on productivity than any other type of transport infrastructure. Pereira and Andraz (2010) claim that the magnitude of the effects of infrastructure investment is debatable, but there is a consensus about the positive sign of the effect. According to Deng (2013) and Canning and Bennathan (2000), the effect of transport infrastructure depends on the development level of the country. There are numerous empirical studies which focus on regions in developed countries in the literature (Khadaroo and Seetanah, 2008), but for fast-growing economies the number of studies is rather limited.

Table 1. Various empirical studies that employ the Cobb–Douglas production function

Year	Author(s)	Country	Time Period	Estimation	Input	Elasticity
1990	Munnell	USA	1970-1986	OLS	Highway	0.06
1991	Duffy-Deno	USA	1970-1978	OLS	Roads	0.096
1992	Garcia-Mila and McGuire	USA	1969-1983	OLS	Highway	0.045
1994	Evans and Karras	USA	1970-1986	OLS	Highway	-0.62
2005	Cantos et al.	Spain	1965-1995	IV	Transport	0.042
2006	Berechman et al.	USA	1990-2000	OLS	Highway	0.047
2007	Moreno and Lopez-Bazo	Spain	1965-1997	OLS	Transport	0.029
2007	Yamaguchi	Japan	1985-2000	3SLS	Air	1.58
2008	Sloboda and Yao	USA	1989-2002	OLS	Transport	-0.016
2011	Jiwattanakulpaisarn	USA	1984-1997	2SLS	Highway	0.060
					Telecom.	0.27
2012	Del Bo and Florio	EU	2006	2SLS	Road	0.08
					Total	0.113
2013	Tong et al.	USA	1981-2004	OLS	Road	0.09
					Rail	-0.05
2013	Yu et al.	China	1978-2009	SDM	Transport	0.114
2013	Chen and Haynes	USA	1991-2009	OLS	Highway	0.117
					Railway	Insignificant

Transport infrastructure investments have evidently been a substantial policy vehicle for regional policy-makers in Turkey; however, advanced literature that focuses on the effects of the transport infrastructure is rare. On a regional level, Önder et al. (2010) analyze the linkages between transportation capital stock and regional economic convergence at a NUTS 2 level in Turkey for the time period 1980 to 2001. The results of a conditional convergence model suggest that transportation capital stock drives larger regional disparities in Turkey. To diminish regional disparities in Turkey, they propose that policy-makers should locate more transportation infrastructure investments in the least developed regions. More recently, Akyelken (2015) pointed to the importance of human capital on local economic returns by investigating the effects of transport infrastructure in Turkish NUTS 1 regions. Finally, Celbiş et al. (2015) claim that land, seaport, and air infrastructure have played an important role in regional exports between 2002 and 2010.

3. Methodology and data

It is an accepted approach in the literature to measure the role of transport infrastructure stock in economic performance by means of a production function since the early work of Aschauer (1989). As Rietveld (1989) notes, the Cobb-Douglas production function is the most preferred function for investigating this link.

In this study, we use an augmented Cobb-Douglas production function approach to estimate the contribution of transport infrastructure to Turkish NUTS 2 regions. We add transport infrastructure stock as an input to the production function, and measure the impact on regional output along with other inputs such as private capital, labour and human capital. This augmented production function model that we use can be expressed as:

$$Y_{it} = K_{it}^{\alpha} L_{it}^{\beta} H_{it}^{\gamma} T_{it}^{\delta} \quad (1)$$

where Y, K, L, H, T, i, and t denote, respectively, the output, private capital, labour force, human capital, transport infrastructure stock, region, and time. Taking the log of both sides of equation (1), we have the following:

$$LnY_{it} = \alpha LnK_{it} + \beta LnL_{it} + \gamma LnH_{it} + \delta LnT_{it} \quad (2)$$

Employing panel data has several advantages (Hsiao, 2007) including identification and controlling individual-specific effects which can be correlated with other variables in the model (Hausman and Taylor, 1981) and allowing more efficient estimations than cross-sectional data (Baltagi, 2011). We use both cross-sectional and panel data in our analyzes with an emphasis on the endogeneity between regional output and transport infrastructure stock which is one of the main criticisms of methods for estimating the production function as indicated in Section 2. That is why equation (2) is estimated by a 2SLS-estimation procedure which is the most frequently used IV estimator (Murray, 2006)- for cross-sectional data and the Hausman-Taylor IV estimator which produces estimations of time-invariant instrumental variables for panel data to overcome the endogeneity problem.

Table 2. Descriptive statistics of the variables

Variable	Observations	Std. Dev.	Min	Max
Y	572	0.456	5.786	7.636
K	442	1.104	-3.677	1.369
L	208	0.598	12.117	15.253
H	312	90.211	1	312
Transport Infrastructure Variables				
Road	442	0.182	3.979	4.801
Motorway	168	0.959	-1.686	4.092
Railway	425	0.547	1.046	3.700
PCA land	168	1	-2.258	2.298
PCA air	572	0.999	-2.414	0.613
PCA telecom	130	1	-1.811	3.131
PCA total	125	36.228	1	125
Instrumental Variables				
Arable land	572	14.304	9	60
Elevation	572	486.876	10	1586.75

Finding appropriate data at the subnational level in Turkey is a problematic process due to the changes in data gathering by the Turkish Statistical Institute (Turkstat). No GDP data has been available for 81 Turkish provinces since 2001. Starting from 2004, instead of provincial data, Turkstat introduced GVA data for 26 NUTS 2 regions. Another problem with the data is the unavailability of private capital stock at the regional level. As proposed by Moody (1974), we use industrial electricity consumption per capita as a proxy for private capital stock. Next, we also employ the percentage of university graduates in the total population of the region to represent the human capital variable in the production function.

Since different types of transport infrastructure have different effects on regional economic performance, we disaggregate the transport infrastructure stock into seven variables (see Table 2) to measure the various impacts of land, air, and telecommunication infrastructure. According to the Ministry of Development statistics, for the last decades, land infrastructure has the biggest share in the transport infrastructure investments in Turkey. Considering this, we estimate the contribution of road, motorway, railway, and (a principal component of) land infrastructure stock separately. There has also been a rapid increase in the number and the size of the airports in the Turkish regions. Between 2003 and 2011, the number of the airports doubled to reach a total of 53, while the number of the passengers increased 7 times and reached 76,1 million for domestic flights (Ministry of Transport, Maritime Affairs and Communication, 2014). The effect of this boost is measured with the principal component of the size and number of airports in the regions from 1990 to 2011. Along with the development of telecommunication technology, there was also a rapid increase in researchers` interest in the link between telecommunication infrastructure and economic growth. Most of the empirical studies conclude that the provision of telecommunication infrastructure is a crucial factor for promoting regional and national economic growth (see, e.g., Hardy, 1980; Datta and Agarwal, 2004; Ding et al., 2008). A principal component analysis of the number of fixed telephone access lines, the capacity for fixed telephones and the number of mobile telephone subscriptions is used in this study to analyze the impacts of telecommunication infrastructure.

As highlighted in the infrastructure literature, the way of measuring transportation infrastructure investments plays an important role in obtaining realistic results. While monetary measures are easy to collect, many researchers- such as Bröcker and Rietveld (2009) and Vickerman (2007)- state that a monetary measurement of transport infrastructure stock is less accurate than physical measurement. Therefore, following Jiwattanakulpaisarn et al. (2011), we utilize the length (km) of the land infrastructure standardized with the total area of the region and the area (m^2) of the air transport infrastructure (see Table 3). We will now employ those data as ingredient for an applied econometric analysis.

Table 3. Definitions of variables

Variable	Year Coverage	Description	Data Source
Y	1987-2011	GVA per capita in 1998 prices	Turkstat
K	1995-2011	Industrial electricity consumption per capita	Turkstat
L	2004-2011	Labour force	Turkstat
H	2000-2011	University graduates divided by total population	Turkstat
Road	1995-2011	Road infrastructure (km) divided by total surface area (excluding lakes)	Turkstat
Motorway	1995-2011	Motorway infrastructure (km) divided by total surface area (excluding lakes)	Turkstat
Railway	1995-2011	Railway infrastructure (km) divided by total surface area (excluding lakes)	Turkstat
PCA land	1995-2011	Principal component analysis of road, motorway , and railway density data	Turkstat
PCA air	1990-2011	Principal component analysis of terminal size and landing area (m^2) of the airports, number of airports data	Ministry of Transport, Maritime Affairs and Communication
PCA telecom	2007-2011	Principal component analysis of number of fixed telephone access lines, capacity for fixed telephones and number of mobile telephone subscriptions	Ministry of Transport, Maritime Affairs and Communication
PCA total	2007-2011	Principal component analysis of road, railway density, number of terminal size and landing area of the airports, number of airports, fixed telephone access lines, capacity for fixed telephones and number of mobile telephone subscriptions	Turkstat and Ministry of Transport, Maritime Affairs and Communication
Arable land	Constant	Arable land (ha) divided by total surface area (excluding lakes)	Turkstat
Elevation	Constant	Average elevation (m) of the centre of the provinces in the regions	Google Earth

4. Empirical Results

We started our analysis with an OLS estimation with time effects to benchmark with other previous estimations. According to the OLS estimation results in Table 4, provincial roads, motorways and (the principal component of) land and telecommunication infrastructure all have a strongly significant and positive effect, while railway and air transport infrastructure have no effect on regional GVA in Turkey. It is neither surprising to find that telecommunication infrastructure has the highest elasticity with 0.33, followed by road infrastructure with 0.29. The principal component of the total transport infrastructure variable (column 7) also suggests that the transportation infrastructure is one of the most important determinants of regional economic performance in Turkey.

Table 4. Results of the OLS estimation

Dep. Var Y	*1*	*2*	*3*	*4*	*5*	*6*	*7*
K	0.1354***	0.0912***	0.1662***	0.0578*	0.1650***	0.1275***	0.1649***
	(0.0159)	(0.0199)	(0.0143)	(0.0224)	(0.0133)	(0.0145)	(0.0157)
L	0.3409***	0.3549***	0.3542***	0.3351***	0.3326***	-0.1918	0.2680***
	(0.0218)	(0.0321)	(0.0242)	(0.0318)	(0.0223)	(0.1065)	(0.0302)
H	0.0017***	0.0029***	0.0016***	0.0030***	0.0016***	0.0016***	0.0016***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Road	0.2915**						
	(0.0913)						
Motorway		0.0760***					
		(0.0196)					
Railway			-0.0327				
			(0.0278)				
PCA Land				0.0988***			
				(0.0210)			
PCA Air					-0.0120		
					(0.0253)		
PCA Telecom						0.3310***	
						(0.0652)	
PCA Total							0.0020***
							(0.0005)
Constant	0.711	1.597***	1.950***	2.014***	2.149***	9.249***	2.985***
	(0.540)	(0.409)	(0.309)	(0.428)	(0.301)	(1.428)	(0.394)
R^2	0.842	0.919	0.839	0.925	0.834	0.872	0.871
Observations	208	89	200	89	208	130	125
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

As a second step in our study, we estimated the production function model with a panel data approach. Choosing the best specification is one of the most debated issues in panel data studies. Following Baltagi (2005), we preferred to employ a fixed-effects model which is an appropriate specification since we focus on the effects for regions. The results of the Hausman test also confirmed the validity of the adoption of the fixed-effects models. Table 5 shows that after controlling for region-specific effects, only road and motorway infrastructure have positive impacts on regional output, while other transport infrastructure variables seem to have no significant impact. To obtain a better understanding of the significance of the regional effects, one might evaluate the F-test results. All fixed-effect models in Table 5 have statistically significant F-test results, which suggest that the OLS estimations are biased and inconsistent because of omitting these significant region dummies.

Table 5. Results of the fixed-effect estimation

Dep. Var Y	**1**	**2**	**3**	**4**	**5**	**6**	**7**
K	0.1787***	0.0757*	0.1658***	0.0572	0.1752***	0.0642**	0.0678**
	(0.0230)	(0.0343)	(0.0230)	(0.0335)	(0.0234)	(0.0238)	(0.0244)
L	-0.0588	0.3004***	-0.0576	0.3391***	-0.0814	0.2035**	0.1930**
	(0.0538)	(0.0780)	(0.0542)	(0.0850)	(0.0544)	(0.0601)	(0.0644)
H	0.0002	0.0003	0.0001	0.0003	0.0003	-0.0001	-0.0001
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0003)
Road	0.3023*						
	(0.1301)						
Motorway		0.0588*					
		(0.0223)					
Railway			-0.0329				
			(0.0437)				
PCA Land				0.0507			
				(0.0262)			
PCA Air					0.0060		
					(0.0216)		
PCA Telecom						-0.0821	
						(0.0586)	
PCA Total							0.0037
							(0.0002)
Constant	6.222***	2.7131*	7.6401***	2.3069	7.8433***	4.2260***	4.3744***
	(0.9862)	(1.0722)	(0.7326)	(1.1632)	(0.7253)	(0.80526)	(0.8572)
R^2	0.826	0.872	0.817	0.866	0.820	0.658	0.650
F-test	80.09	111.94	85.54	98.70	81.75	82.52	81.74
Observations	208	89	200	89	208	130	125
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The next step is performing a 2SLS estimation to overcome a possible endogeneity problem between GVA per capita and transport infrastructure measures. Following Ramcharan (2009) and Del Bo and Florio (2012), we used two geographical instrumental variables to instrument transport infrastructure. It is crucial to check the validity of the instrumental variables with preliminary tests. All models with instrumental variables passed the threshold of 10 according to the F-test results which gives evidence of the validity of the instrumental variables. We also tested our instrumental variables with the weak identification Cragg-Donald F-statistic test, and confirmed that the models do not suffer from the weak instrument problem except for Model 3 and Model 6. Lastly, we performed the Sargan test for detecting the over-identification problem, and found that the instruments are valid and uncorrelated with the error term.

The results of the 2SLS estimation indicate that road (Model 1), motorway (Model 2), PCA land (Model 4) and PCA total (Model 7) positively affect regional output, while, somewhat surprisingly, telecommunication and air transport infrastructure have no impact. A comparison of the 2SLS and the OLS findings using the Hausman test suggests that the 2SLS results are consistent. Since our two geographical instrumental variables are time-invariant, it is not possible to use a fixed-effects instrumental variable estimation. Instead, we employ the Hausman-Taylor

IV estimation which is very popular because it is an easy and effective procedure (Mátyás and Seveste, 2008). The results of the Hausman-Taylor IV estimation are shown in Table 7. According to the results which are similar to the fixed-effects results in Table 5, road, motorway, and land infrastructure have positive and significant effects on regional output. The other infrastructure types seem to have no obvious impact; this finding calls for specific infrastructure research for airports and telecommunication in the future.

Table 6. Results of the 2SLS estimation

Dep. Var Y	*1*	*2*	*3*	*4*	*5*	*6*	*7*
K	0.069**	0.023	0.345***	-0.055	0.127***	0.244**	0.254***
	(0.026)	(0.035)	(0.088)	(0.063)	(0.027)	(0.083)	(0.048)
L	0.361***	0.201**	0.627***	0.172	0.361***	2.862	-0.016
	(0.024)	(0.070)	(0.137)	(0.090)	(0.032)	(1.945)	(0.137)
H	0.002***	0.004***	0.001	0.004***	0.001***	0.002***	0.001**
	(0.0002)	(0.000)	(0.0005)	(0.0004)	(0.0002)	(0.001)	(0.0003)
Road	0.912***						
	(0.212)						
Motorway		0.226***					
		(0.060)					
Railway			-0.918*				
			(0.405)				
PCA Land				0.263**			
				(0.086)			
PCA Air					-0.295		
					(0.168)		
PCA Telecom						-1.854	
						(1.22)	
PCA Total							0.0095**
							(0.003)
Constant	-2.377*	3.33***	1.516	4.161***	2.892***	-32.689	6.455***
	(1.101)	(0.4110)	(0.394)	(1.193)	(0.735)	(26.080)	(1.692)
R^2	0.805	0.858	-0.023	0.865	0.728	-0.044	0.594
Observations	208	89	200	89	208	130	125
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cragg-Donald Wald F statistic	53.978	7.297	2.730	7.905	7.083	1.327	6.801
Sargan (p value)	-	0.281	0.306	-	-	0.801	-
Instruments	Elevation	Elevation	Elevation	Arable Land	Arable Land	Elevation	Elevation
		Arable Land	Arable Land			Arable Land	

Table 7. Results of the Hausman-Taylor IV estimation

Dep. Var Y	*1*	*2*	*3*	*4*	*5*	*6*	*7*
K	0.179***	0.088**	0.169***	0.073*	0.188***	0.076***	0.077***
	(0.022)	(0.032)	(0.221)	(0.031)	(0.022)	(0.022)	(0.023)
L	0.013	0.326***	0.011	0.375***	0.004	0.237***	0.229***
	(0.049)	(0.069)	(0.0493)	(0.074)	(0.048)	(0.055)	(0.054)
H	0.0004*	0.0005*	0.0002	0.0004*	0.0004*	0.0002	0.0003
	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Road	0.278*						
	(0.129)						
Motorway		0.065**					
		(0.022)					
Railway			-0.013				
			(0.042)				
PCA Land				0.062*			
				(0.024)			

PCA Air					0.001		
					(0.021)		
PCA Telecom						-0.018	
						(0.046)	
PCA Total							0.000
							(0.000)
Constant	5.666***	2.329*	7.042***	1.701	6.933***	3.891***	3.972***
	(0.989)	(0.979)	(0.704)	(1.101)	(0.676)	(0.750)	(0.742)
Observations	208	89	200	89	208	130	125
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region effects	Random	Random	Random	Random	Random	Random	Random
Instruments	Elevation	Elevation	Elevation	Arable Land	Arable Land	Elevation	Elevation

5. Concluding remarks

Since the beginning of the new century, Turkish governments have been heavily investing in building and improving the transport infrastructure stock in order to have a reliable and efficient transport network. At the beginning of the 2000s, the total length of the divided ways in the country was 6.101 km, and in less than ten years this number has increased to 23.522 km. However, this serious change in the transport infrastructure stock has attracted little attention from researchers. To our knowledge, this study is the only attempt to measure the latest developments of transportation infrastructure in 26 NUTS 2 regions in Turkey with different econometric specifications.

In this study, despite of the data limitation and hence the small sample size problems, we have tried to estimate the output elasticity of transport infrastructure in Turkish regions with OLS, 2SLS, fixed-effects and Hausman-Taylor IV estimators for both cross-section and panel data. The most striking finding is that, regardless of the estimation method, road and motorway infrastructure appear to have always significant and positive effects on regional GVA. Considering the huge investments in building new airports and expanding existing airports, it is surprising to find that air transport infrastructure has no significant regional impact. It seems plausible that airports tend to have specific geographical, point-oriented (or node-determined) impacts within a region, and less region-wide systemic impacts, so that such spatial effects are perhaps less observable. In the same vein, it is not unlikely that telecommunication infrastructure - as a spatial network facility - is less able to provide a relatively discriminating and positive contribution to overall regional growth, when only broad regional effects are included in a cross-sectional model. It is thus conceivable that telecommunication has less specific, spatially discriminating effects, and has most likely more generic, system-wide effects.

Our findings, which might have implications for policy makers, indicate that roads and motorways are important for reaching regional economic goals. Clearly, focusing on building new roads and improving existing ones have promote regional output growth by providing a better connected transport infrastructure network between all Turkish regions, and have a productivity rise, however, before adopting and conducting a solid transport infrastructure policy, it is crucial to understand the nature of the positive effect of transport infrastructure; is it a one-time boost or long-term productivity growth instrument? Also, policy-makers should take into account that transport infrastructure only creates the necessary conditions for accomplishing regional development (Nijkamp, 1986). It is one of the major contributors of the economy, but an advanced transport infrastructure alone is not sufficient for regional development. That is why transport infrastructure-based regional development policy solely would not be useful in the long run. Another important point for policy-makers is the space-time allocation of the infrastructure investments. Instead of constructing new roads in an already connected transport network with central government decisions, one might commission to remove bottlenecks in the network using practical local information from local governments. Finally, as one of the goals of the National Regional Development Strategy (Ministry of Development, 2015), connecting trade center regions with disadvantaged regions and a provision of a better accessibility through new transport infrastructure for both developed and less developed regions might generate possible negative spillovers. Scanty production factors in less developed regions might then migrate to the nearest and more developed regions. For this reason, investing in an intra-regional transport infrastructure network (Vickerman, 1995) should also be one of the major goals of regional development policies. For future research, it would be beneficial for both academic and policy making purposes to analyze the transport infrastructure considering also spillover effects with recent available province level data.

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