European Regional Science Association

Rail Infrastructure Investment and the Effects of Regulatory Change

by

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Note

Analysis for this study is still underway.

Please do not quote any content yet.

Main Purposes and Contributions

- **Main Purposes**：To find **determinants of investment decisions** on rail infrastructure and facilities, especially **regulatory factors** on investment decisions
- **Remaining Issues** from Previous Research and **Major Contributions** of this Study
  - There are **few studies** on estimation of investment function in the **railway** industry.

    ＝＞This study estimates empirical investment function in the railway industry.
  - Previous studies on investment function in the transport industry use a simple regression analysis. There is **no well** constructed investment function with **background of theory**.

    ＝＞The model in this study is modified from the **acceleration model** with **stock adjustment**.
  - In previous studies, **no regulation factors** (entry regulation, vertical structure, ownership, market structure) are considered.

    ＝＞This study considers regulation factors in the investment function by using OECD's regulation index.

Literature Review

(1) Investment Model in General Economic Theory

(i) **Managerial Efficiency of Investment** => If net present values of earning (the difference between revenues and costs) for capital stock is positive, then the investment is worth it.

(ii) **Acceleration Principle** => Investment is dependent upon not the interest rate but the change in GDP. The acceleration principle assumes a fixed technology coefficient, which states that in order to achieve a certain amount of output, capital is required in proportion .

(iii) **Stock Adjustment Model** => The difference between the optimal capital stock, which is considered desirable for the current period, and the actual capital stock at the end of the previous period is considered not to be fully, but only partially, realized for the current period.

(iv) **Jorgenson's Neoclassical Model** => A distinctive feature of the neoclassical model for investment is that it is based on an explicit model of optimizing behavior, relating the desired capital stock to interest rates, output, capital prices, and taxation.

(v) **Tobin's q** => The q is defined as a measure which is the total market value of equity and liabilities of the firm divided by the total book value of these of the firm. Corporate managers make capital investment decisions based on this q .

(2) Investment Model in the Transport Industry

- There is limited previous research on the estimation of the investment function, for example,

  Railways: Moriya (1991) , Looney and Frederiksen (1998)

  Urban transport (rail and bus): Levine (2013)

  Roads: Cervero and Hansen (2002)
- These studies in general simply apply regression analysis to find the determinant factors for investment.
- They are practical but lack a strong theoretical basis.
- In empirical models, explanatory factors for investment are commonly used

  (i) service output (e.g. number of passengers, average distance traveled),

  (ii) socioeconomic factors (e.g. population, employment density, income level, GDP),

  (iii) financial factors related to investment (e.g. long-term interest rates).

(3) Transportation Investment and Its Effect

- There are many studies on the impact of transportation investment on regional economies, for example

  (i) Kohler et al. (2008): a simulation model to analyze the GDP growth from transport investment in 17 EU countries.

  (ii) Recently, there have been many analyses on the impact of high-speed rail construction on local economies: Chen et al. (2016), Kim and Yi (2019), Chen (2019).

  (iii) Graham (2007) : analysis of externalities due to transport projects in UK.

- These studies:

  Regional economy = *f* (**investment** in railway, other factors)

  This study: **Investment** in railways = *f* (several factors).

(4) Regulations and Unbundling

- In recent years, there have been a number of studies on **the impact of regulation and unbundling** in utilities, including transportation projects.
- Railway industry

  (i) Costs and productivity:

  Cantos et al. (2010), Mizutani and Uranishi (2013), Mizutani et al. (2015) and so on.

  (ii) Demand: Tomeš (2017) and Mizutani (2019).

  (iii) Survey of recent studies of the effect on efficiency:

  Abbott and Cohen (2017)
- However, there exist no studies on investment.

Model and Data

Major Steps to get Investment Function for Rail Infrastructure

[*Capital stock formation*] $G_t \equiv (1-\delta)G_{t-1} + I_t$ => $I_t \equiv (G_t - G_{t-1}) + \delta G_{t-1}$

Investment for renewal

Net investment

where δ: depreciation ratio for public capital,

G_t, G_{t-1} : capital stock at year t, at year $t-1$

I_t: total investment in rail infrastructure

[*Investment based on the acceleration model*]

$$I_t \equiv (G_t^* - G_{t-1}) + \delta G_{t-1}$$
$$G_t^* = \mu Y_t$$

where G_t^*: optimal capital stock (rail infrastructure),

Y_t: output of railway industry,

μ: fixed capital/output ratio.

[*Stock adjustment*] However, capital is not adjusted by one time period. Capital stock is a part of capital formation, which is expressed as $(G_t^* - G_{t-1}) + g_t$.

$$I_t = (\mu Y_t - G_{t-1}) + g_t + \delta G_{t-1} = \mu Y_t + g_t + (\delta - 1)G_{t-1}$$

[*Factors affecting the gap: Assumption*]： Three factors affect the gap of capital stock per rail capital stock: (i) demand conditions (DM_t), (ii) regulatory conditions (REG_t), and (iii) managerial conditions (MG_t).

$$g_t = f(DM_t, REG_t, MG_t)$$

[*Obtained investment model*] $I_t = \mu Y_t + f(DM_t, REG_t, MG_t) + (\delta - 1)G_{t-1}$

Basic Investment Model

The basic model is modified from the acceleration model with stock adjustment.

$I = \mu Y + f(DM, REG, MG) + (\delta - 1)G_{-1}$,

where, I: total investment for rail infrastructure,

Y: output of railway industry,

DM: demand conditions,

REG: regulatory conditions,

MG: managerial conditions,

G_{-1}: capital stock in the previous year,

μ: fixed capital/output ratio,

δ: depreciation ratio for public capital.

Empirical Investment Function

$$\ln I = \alpha + \beta lnY + \sum_k \gamma_k lnDM_k + \sum_l \theta_l lnREG_l + \sum_m \nu_m lnMG_m + \lambda lnG_{-1} + \tau CRS + DEU$$

Where, I: total investment for rail infrastructure,

G_{-1}: capital stock in the previous year (route-km),

Y : output of railway industry (train-km),

DM_k: demand conditions(k=*popden* (population density), *gdp* (GDP per capita), *comp* (competition with other modes), *hsprl* (high-speed train ratio)),

REG_l: regulatory conditions(l= *enty* (entry regulation), *pub* (public ownership), *vert* (vertical structure), *mkt* (market situation)),

MG_m: managerial conditions(m=*govdeb* (government's debt ratio), *acdrat* (accident ratio),

CRS: financial crisis time index ($2008 = 1, 2009 = 2, \cdots, 2013 = 6$),

DEU: EU dummy variable (EU countries =1, others =0)

Data and Estimation Methods

- Data collection and analysis unit: Country-basis
  Countries：29 OECD countries (AUS, AUT, BEL, CAN, CZE, DNK, EST, FIN, FRA, DEU, GRC, HUN, IRL, ITA, JPN, KOR, LUX, NLD, NOR, POL, PRT, SVK, SVN, ESP, SWE, CHE, TUR, GBR, USA)

  Year：from 1995 to 2013, 19 years , Number of observations：536 observations
- Correlation check : Correlation between explanatory variables was checked in order to avoid multicollinearity. Other: Estimations by using estimated capital stock values instead of route-km are checked. ＝>Results are unstable.
- Estimation methods： The endogeneity was checked. =>There exists an endogeneity problem. => Estimation by 2SLS, GMM：endogenous variables (population density, GDP per capita), Instrument variables (rail network length per land square km, urban population ratio, and industrial employment ratio)

Regulatory Index of OECD: Rail Industry

Regulatory Index	Explanation	Note
Overall	0 (least regulated) 6 (highly regulated)	Average of Index from Entry to Market structure
Entry regulation	0 (free entry), 2 (entry franchised to several firms), 4 (entry franchised to several firms, each having exclusive right), 6 (entry franchised to a single firm)	
Public ownership	0 (full private ownership) 6 (full public ownership)	This index (% x 6) is calculated based on percentage of ownership（%). Rail operation and infrastructure are 50% each.
Vertical structure	0 (ownership separation), 3 (legal separation), 4.5 (accounting separation), 6 (no separation=vertical integration)	
Market structure	0 (more than 2 firms in the market), 3 (duopoly), 6 (monopoly)	

（Source）：Koske, I., I. Wanner, R. Bitetti and O. Barbiero (2015) "The 2013 Update of the OECD's Database on Product Market Regulation: Policy Insights for OECD and Non-OECD Countries," OECD Economics Department Working Papers, No.1200, OECD Publishing.

Summary of Statistics of Selected Variables

Variable	Definition	Mean	Standard Deviation	Minimum	Maximum
I (Rail investment)	Rail investment (2010 US million $ per year)	2,610	3,350	3.58	15,600
Y (Output)	1000 Train-km per year	218,733	301,519	6,139	1,350,808
G_{-1} (Capital stock in the previous year)	Route-km in the previous year (km)	16,767	35,602	275	228,999
DM_{popden} (Population density)	Person per square km	139.026	122.635	2.344	515.257
DM_{gdp} (GDP per capita)	GDP per capita (2010 US$ per person)	38,139	21,328	6,540	111,968
DM_{pcomp} (Passenger rail competitive situation)	% of rail share in terms of passenger-km	7.553	5.769	0.150	30.873
DM_{fcomp} (Freight rail competitive situation)	% of rail share in terms of tonne-km	21.859	17.444	0.592	71.288
DM_{hsprl} (High-speed train ratio)	% of high-speed rail line in total rail network	1.631	3.195	0.000	14.700
REG_{enty} (Entry regulation)	Regulatory index between 0 and 6	2.996	2.198	0.000	6.000
REG_{pub} (Public ownership)	Regulatory index between 0 and 6	5.088	1.706	0.000	6.000
REG_{vert} (Vertical structure)	Regulatory index between 0 and 6	3.963	1.429	0.000	6.000
REG_{mkt} (Market structure)	Regulatory index between 0 and 6	3.960	2.028	0.000	6.000
MG_{gobdeb} (Government debt)	% of total central government debt in GDP	47.537	32.713	0.800	183.500
MG_{acdrat} (Rail accident ratio)	Number of accidents per 1000 train-km per year	3.122	5.606	0.000	40.624
DEU (EU Dummy)	EU member state = 1, others = 0	0.627	0.484	0.000	1.000
CRS (Financial crisis index)	Year 2008 = 1 and since then every year add 1 until 2013	1.116	1.890	0.000	6.000

Results

Examples of Results: Cases of 2SLS

Model	Model 1	Model 2	Model 3
Train-km (Y)	0.9460*** (0.1267)	1.0761*** (0.1297)	0.9486*** (0.1285)
Capital stock: rail network (G_{-1})	0.1478 (0.1320)	0.0711 (0.1306)	0.17481 (0.1302)
Population Density (DM_{popden})	-0.0270 (0.0547)	-0.0384 (0.0541)	-0.0084 (0.0545)
GDP per capita (DM_{gdp})	0.8917*** (0.1496)	0.8219*** (0.1374)	0.8820*** (0.1382)
Passenger rail competition (DM_{pcomp})	0.1132* (0.0759)	0.0517 (0.0800)	0.0698 (0.0794)
Freight rail competition (DM_{fcomp})	-0.3622*** (0.0469)	-0.3468*** (0.0451)	-0.3435*** (0.0480)
Highspeed-train ratio (DM_{hsprl})	0.0166*** (0.0068)	0.0125* (0.0069)	0.0152*** (0.0068)
EU Dummy (DEU)	0.0391 (0.0806)	-0.0635 (0.1018)	-0.0735 (0.1008)
Financial crisis index (CRS)	0.0820*** (0.0185)	0.1028*** (0.0195)	0.0907*** (0.0195)

Model	Model 1	Model 2	Model 3
Entry regulation (REG_{enty})	-	0.0786*** (0.0198)	-
Public ownership (REG_{pub})	-	0.0088 (0.0228)	0.0315 (0.0235)
Vertical integration (REG_{vert})	-	-0.0886*** (0.0321)	-0.0891*** (0.0337)
Market Structure (REG_{mkt})	-	-	0.0481** (0.0231)
Government debt ratio (MG_{govdeb})	-0.0804* (0.0526)	-0.1158** (0.0540)	-0.1030* (0.0540)
Rail accident ratio (MG_{acdrat})	0.2373*** (0.0695)	0.2444*** (0.0665)	0.2289*** (0.0672)
Constant	-6.1709*** (1.8494)	-6.8531*** (1.7988)	-6.2771*** (1.7771)
adj.R squared	0.7786	0.7914	0.7872

Statistical significance at 1% (***), 5% (**), 10% (*)

Summary of Effect on Investment

Kinds of factors	Effect on Investment		
	Positive effect (+)	Negative effect (-)	Not significant effect
Demand conditions	(i) Output (train-km), (ii) GDP per capita, (iii) High-speed train ratio	(i) Freight service competitive ratio	(i) Passenger service competitive ratio, (ii) Rail capital stock (rail network length)
Regulatory conditions	(i) Vertical separation	(i) Less entry regulation, (ii) Competitive market structure	(i) Public ownership
Managerial conditions	(i) Rail accident rate	(i) Government debt ratio	
Controlling factors	(i) Financial crisis index		(i) EU dummy

Intuition on Regulatory Factor for Investment

- Vertical separation has a positive impact on investment, perhaps because it promotes more investment through the specialization of business activities. => Gov't could focus on infrastructure investment.
- Entry regulation increases and the market situation becomes less competitive, investment grows. Presumably, most investment is by the national government, and the number of existing railways in the market is not multiple. Therefore, the analysis leads to the result that a stabilized situation generates more investment.

Thank you very much for your attention.

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