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Summary

During the past two decades, numerous studies have been undergone on macro-economic effects of public investment including transport infrastructure. Not much attention, however, has been paid to effects of actual accessibility realized by transport industry and infrastructure on macro economic performance. Incorporating inter-regional accessibility index as an economic environment determinant in Cobb-Douglas production function and Barro regression framework, cross-sectional regression was undertaken using panel data of 47 prefectures in Japan. Analysis reveals that there has been significant productivity gain from improvement in air transport accessibility between 1995 and 2000 particularly for agglomerated areas such as the Tokyo metropolitan region[1].

Introduction

During the past two decades numerous attempts have been undertaken to elucidate reasons behind stagnating economic performance. Aschauer (1989) followed by Munnell (1990a, 1990b) triggered discussions on importance of public infrastructure on productivity. In their works, poor economic performance was attributed to the deteriorating public infrastructure. Subsequent studies that employed the same technology, however, yielded mixed result. Holtz-Eakin (1994), Mas (1996) and Strum (1998) contends that empirical evidence of public capital's impact on output is at best *fragile*. Cobb-Douglas specification was criticized in a number of grounds.

Another vein of analysis on effects of public investment on economic performance was the neoclassical growth model developed by Solow (1956) and Swan (1956), empirical work of which was pioneered by Barro (1991) and Mankiw *et al*. (1992). Using the cross-section regression, Easterly and Rebelo (1993) found that public investment in transport and communication is robustly correlated with growth. In terms of transport and growth, Ades and Glaeser (1999) revealed that openness represented by rail development and distance to port has significant positive effect to growth in less urbanized area using US data in the 19th century. Also, Bougheas *et al*. (1999) showed that, *ceteris paribus*, level of infrastructure, which reduces cost of transport, has positive effect on volume of trade.

Another growing interest with respect to effect of transport cost on economic performance is the *new economic geography*. Fujita, Krugman and Venables (2001)

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[1] This paper was first presented at Air Transport Research Society (ATRS) World Conference 2005, Rio de Janeiro, Brazil, July, 2005.

suggest that geography of economic growth is self-organizing in nature with agglomeration forces and transport cost serving as engines. There has not been much empirical study conducted in this field, but from public policy's point of view, it is important to understand whether improvement in transport would lead to more agglomeration or facilitate catching up by peripheral areas.

Japan had not been the exception of debates on effectiveness of public investment. The discussion, however, was from a somewhat different perspective. During the economic dismay during the decade of 1990's public investment on social overhead (Ig) was doubled reaching 6% of GNP. Concerns were on whether the investment is worth it. Mandatory application of cost benefit analysis in major public investments was introduced to check their efficiency in advance, and *ex post facto*, methodology used by Aschauer and Munnel's was applied to analyze productivity gains from public investments. The results generally showed that marginal productivity gains from public investment have decreased during the 80's and 90's. Effect of transport infrastructure on growth has not been analyzed until recently. Nakazato (2001) applied Barro's approach on road investment in Japanese prefectures through 1960 to 1988 and reported that peripheral areas have positive effect through increased accessibility, although the incremental effect of road investment declined in the 1980's.

In terms of transport infrastructure, not much analysis has been undertaken other than on road development. One reason is that contribution of transport infrastructure, such as airport and railway, depends on how it is utilized. Also even if unit service level of transport could be identified, its significance is subject to economic geography. Transport cost has different meaning depending on whether you are accessing to a core area or to a peripheral region. One such analysis by Yamaguchi and Maku (2003) specified aggregate inter-prefecture and intra-prefecture accessibility index to assess the impact on production function of prefectures in Japan. It revealed that inter-prefecture accessibility improvement had positive and significant effect on output, while intra-prefecture congestion had constrained economic performance in major metropolitan areas. Effect of accessibility on growth, however, is not analyzed.

In this paper two methodologies, Cobb-Douglas production function estimate and Barro regression, are used to access the impact of air transport service on macro economic performance of regions in Japan.

Macro Economic Performance in Japan

Japanese economy experienced steady growth even after the two oil crises and enjoyed average annual growth of 3.2% during the first half of 1980's. Then after G7 meeting at Plaza in 1985, Yen appreciation coupled with excess liquidity in the financial market led the economy into a boom, which eventually turned into an unprecedented recession; burst of the *bubble* (see Figure 1). Although the GDP growth temporally recovered in 1995 and 96, average growth rate from 1992 to 2000 was merely 1%. Government poured in public investment in an endeavor to boost up the economy. Ig against GDP reached 6% during the mid 1990's, the so-called "lost decade." Performance in regional economy was seemingly random. As depicted in Figure 2, discounted for public investment, there were rural prefectures such as Nagano, Oita and Iwate that increased per capital GDP by 3% annually, while Shiga, Kagawa and Okayama that did not reach 1%.

Figure 1

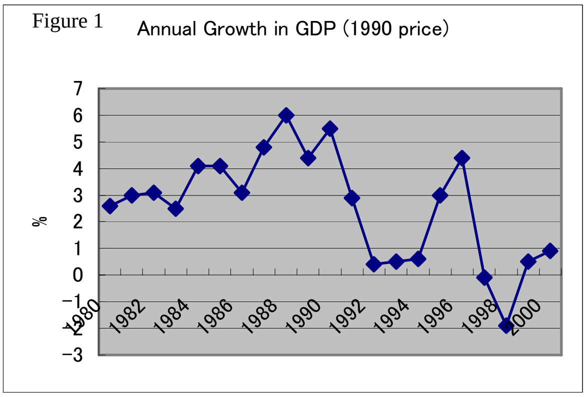
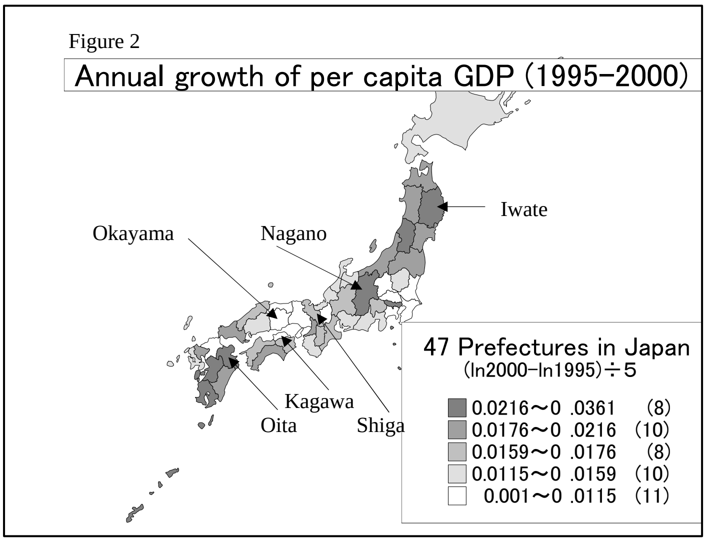


Figure 2



Domestic Air Transport Market in Japan

Today, domestic aviation in Japan has established its role as a major mode in inter-city transportation. The market, however, has gone through history of growth and maturity over half a century to become what it currently looks. Back in the 1960's three major airlines operated orderly in their respective markets; i.e.

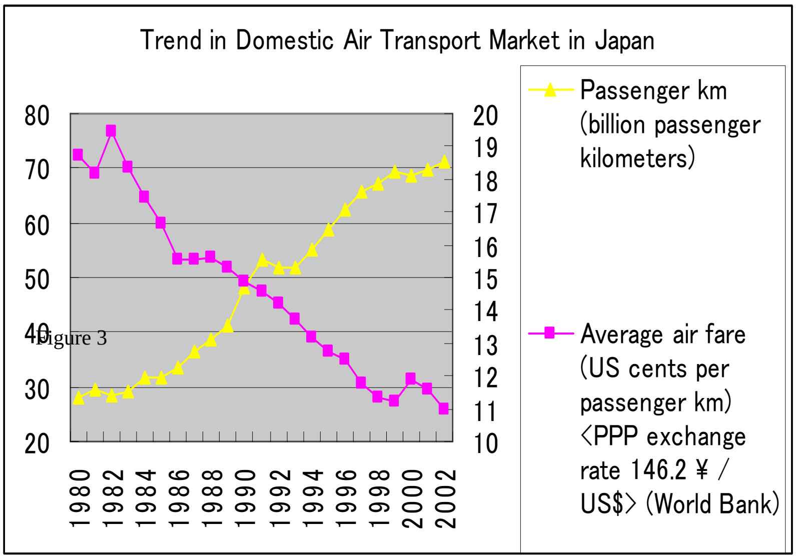


Figure 3

JAL on international and domestic trunk routes, All Nippon Airways (ANA) on domestic trunk and local routes, Japan Air Systems (JAS, ex-Toa Domestic Airlines (TDA)) on domestic local routes. Marked by regulatory reform in 1985, window of competition was opened. Initially route and frequency regulations were deregulated to increase competition followed by airfare deregulation to allow normal and discount fare setting with higher flexibility. Consequently, the ratio of available seats in routes with multiple airlines versus total available seats increased from 53% in 1985 to 81% in 2000. Following these deregulatory steps, two new airline operations were launched in 1998; Skymark Airlines on Tokyo-Fukuoka route, and Hokkaido International Airlines (AIR DO) on Tokyo-Sapporo route. Apart from subsidiaries of the major three companies, it was a new entry in 35 years. Skymark Airlines offered normal fare at half the price and Hokkaido International Airlines at 36% below incumbents' fares. This was accomplished by streamlining onboard service and administrative cost-cuts through outsourcing aircraft maintenance and airport service. As a result, "everyday low fare" strategy won the popularity and the load factor rose as high as 80%. On the contrary, incumbent carriers suffered sudden drop in passengers where new airlines entered. These routes were lucrative trunk routes with high business travel ratio. Faced with such a consequence, the incumbent carriers started to offer discount fares on specific flights just before and after the flights of new entrants. This strategy was quite effective and by March 1999, the incumbent carriers regained their load factor to the same level as that of a year ago. Such competitive force resulted in an annual increase of 16.3% in passengers between Tokyo and Fukuoka, and 9.4% between Tokyo and Sapporo. Route and frequency regulation and prior approval of airfare were finally abolished in 2000.

Airport capacity was increased hand in hand with deregulation. Shortage of take-off and landing slots at congested airports such as Haneda Airport in Tokyo, has not been resolved. Based on Civil Aeronautics Law, the aeronautical authority set out a new policy to review slot allocation in congested airports every five years by indices evaluating consumer benefit and efficiency.

The model and empirical findings

1) Cobb-Douglas Production Function

Let Y_{it} and Y_{jt} be GDP adjusted for public investment in prefecture i and j in year t, L_{it} be labor input in prefecture i in year t, K_{it} be private sector stock in prefecture i in year t, and ACC_{it} be air transport accessibility index between prefecture i and prefecture j $(i \neq j)$ in year t. To impose constant return to scale in private investment and labor input, put $y_{it} \equiv Y_{it} / L_{it}$, $k_{it} \equiv K_{it} / L_{it}$, then, Cobb-Douglas specification of the macro production function including accessibility looks as follows. As discussed in Meade (1952), air transport accessibility should be considered as *atmosphere* rater than un-paid factor. Thus, constant returns to scale is not imposed on ACC_{it}.

$$y_{it} = \{\exp(\beta_0 + \beta ACC_{it})\} k_{it}^{\beta_4} \qquad (1)$$

Taking natural log of formula (1), we get

$$\ln y_{it} = \beta_0 + \beta ACC_{it} + \beta_4 \ln k_{it} + \varepsilon_{it} \qquad (\varepsilon_{it} : \text{random variable}) \qquad (2)$$

Accessibility index is defined as, $ACC_{ijt} = S_{ijt} * \left|\ln y_{it} - \ln y_{jt}\right| / \ln GV_{ijt}$.

GV_{ijt}, generalized cost of air transport between origin and destination prefectures, is composed of out of pocket cost (airfare) and value of time. As for value of time, not only the average travel time of travel but also frequency of air transport is converted into monetary terms and subtracted to reflect the differences in air service intensity. $\left|\ln y_{it} - \ln y_{jt}\right|$ is incorporated to reflect the relative economic level of the origin and destination prefectures since accessibility has different impact on the origin prefecture depending on the counterpart's economic level. Also, share of air transport (S_{ijt}) is to reflect the magnitude of generalized cost of air transport between origin and destination prefectures.

S_{ijt} : Share of air transport between prefecture i and prefecture j in year t

GV_{ijt} : Generalized cost of air transport between prefecture i and prefecture j in year t is defined as, $GV_{ijt} = P_{ijt} + W_t (T_{ijt} - \Omega \ln F_{ijt})$, where,

P_{ijt} : Average air fare from prefecture i to prefecture j in year t

W_t : Value of time calculated from average wage in year t

T_{ijt} : Average time of travel by air from prefecture i to prefecture j in year t

Ω : Frequency conversion ratio derived from air transport demand forecast survey

F_{ijt} : Frequency of air transport between prefecture i and prefecture j in year t

y_{it} y_{jt} : Per capita GDP in prefecture i or j $(Y_{it}/L_{it}, Y_{jt}/L_{jt})$

In order to account for simultaneity, accessibility index model based on partial equilibrium was derived as follows. These functions were set in a simultaneous equation system with the macro production function. Such a simultaneous equation approach of production and public investment, had been taken by Duffy-Deno and Eberts (1991).

The accessibility index model was specified based on Ohashi *et al*. (2003) and Yamaguchi (2005) as follows.

Let number of airlines be n. Aggregate passenger km would be $Q = nq$ where q is demand for a single airline. Let airfare be p. Then revenue for a single airline would be $R = pq$.

Assuming Cournot competition, $MR = \left(\frac{\partial p(Q,GDP)}{\partial Q} \frac{\partial Q}{\partial q} \right) q + p(Q,GDP)$. Since first-order condition for profit maximization in oligopoly is $MR = MC$, $nMR = nMC$.

Therefore, $$n\left(\frac{\partial p(Q,GDP)}{\partial Q} \frac{\partial Q}{\partial q} q + p(Q,GDP) \right) = nMC(q; shift/parameters) \quad \ldots\ldots(3)$$

Assume demand function as follows.

$$p(Q,GDP) = \alpha_0 Q^{\alpha_1} GDP^{\alpha_2}$$

Taking natural log yields $\ln(P) = \alpha_0 + \alpha_1 \ln(Q) + \alpha_2 \ln(GDP) \ldots\ldots(4)$

Assume marginal cost function as follows.

$$MC(q; distance, airshare) = \beta_0 q^{\beta_1} \exp\left[\beta_2(\ln(distance)) + \beta_3(airshare)\right]$$

Following reduced form is derived from (3).

$$\ln(Q) = \frac{\ln(\beta_0 n^{1-\beta_1}) - \ln\{\alpha_0(\alpha_1 + n)\}}{\alpha_1 - \beta_1} - \frac{\alpha_2}{\alpha_1 - \beta_1}\ln(GDP) + \frac{\beta_2}{\alpha_1 - \beta_1}\ln(distance) + \frac{\beta_3}{\alpha_1 - \beta_1}(airshare) \quad \ldots\ldots(5)$$

Equations (2), (4) and (5) were solved simultaneously by 3SLS.

According to Hayashi (2003), instrument variable in a simultaneous equation system should be at least two more than the number of parameters including the exogenous variables in the equation. Following Easterly and Robelo (1993), population and share of agricultural output was included as instruments.

Instrument variables for Cobb-Douglas regression were set as follows:

1) Natural log of private stock in origin prefecture
2) Natural log of labor in origin prefecture
3) Natural log of GDP(origin prefecture)*GDP(destination prefecture)
4) Natural log of distance between origin prefecture and destination prefecture
5) Share of air transport between origin prefecture and destination prefecture
6) Population of origin prefecture
7) Share of agricultural output in origin prefecture

Panel data were made available for 1995 and 2000, since transport survey data were provided for these years only. Data for pairs of prefectures without air service were eliminated, so that the panel data set was composed of 1410 for each year. All the figures were converted to real value based on 1995. Data source of the variables are described in Table 1.

Table 1 Data source of variables

Variable	source
Y_{it}	National Accounts (ESRI,Cabinet Office)
K_{it}	Private sector stock: Doi (2002)
L_{it}	Population census 1995 & 2000 (Ministry of Internal Affairs and Communications)
ACC_{it}	Calculated from Net trunk route passenger travel survey, Air transport demand forecast survey (Ministry of Land, Infrastructure and Transport), National Accounts (ESRI, Cabinet Office) JTB time table, Monthly labor survey (Ministry of Health, Labor and Welfare)

The result of 3SLS is listed in Table2. As expected, ACC_{it} has significantly positive effect on productivity. Also, it should be noted that coefficient for ACC_{it} has increased from 1995 to 2000 suggesting that Japanese prefectures have become more sensitive to air transport accessibility.

Table 2 Cobb-Douglas Simultaneous Equation Estimates (n=1410)

Equation (2)	C	ACC	$\ln(K/L)$	
Parameters for 1995 t statistics	-.493053 -9.22692**	1.57895 3.47719* *	.858261 40.1941**	R^2: .554344
Parameters for 2000 t statistics	-.661276 -10.8640**	1.97635 4.53812**	.868093 39.3313**	R^2: .549413

Equation (4)	C	$\ln(Q)$	$\ln(GDP)$	
Parameters for 1995 t statistics	4.40660 21.8528**	-.261739 -37.7187**	.120226 15.1012**	R^2: .499931
Parameters for 2000 t statistics	3.93308 17.3001**	-.278136 -39.7614**	.145030 16.0286**	R^2: .523761

Equation (5)	C	$\ln(GDP)$	$\ln(Distance)$	$Airshare$	
Parameters for 1995 t statistics	-20.2971 -27.5989**	.830942 38.2947**	1.53817 29.1027**	1.68247 15.2469**	R^2: .624953
Parameters for 2000 t statistics	-24.2923 -31.9708**	.910927 41.4665**	1.78420 33.7457**	1.38539 13.8818**	R^2: .673173

(** significant at 1% level)

2) Barro Regression

Barro regression is specified in the following two forms. First is a basic model with initial per-capita output level and accessibility index as regressors.

$$\frac{1}{T}(\ln y_{it+T} - \ln y_{it}) = \alpha_0 + \beta_0 \ln y_{it} + \gamma_0 ACC^0 + \varepsilon_{it} \ \ldots\ldots(6)$$

where,

$$ACC^0 : airshare * \left|\ln y_{it} - \ln y_{jt}\right| /(GV_{ijt+T} / GV_{ijt}) + \varepsilon_{it}$$

According to Fujita, Krugman and Venables (1999), formation of hierarchical urban system could be accelerated when transport cost is reduced thus leading to agglomerated regions outperforming economic performance of peripheral areas. To test the hypothesis, in the second form, accessibility index is disaggregated into two. One is to reflect a situation in which the origin prefecture has a higher per-capita output than the destination prefecture's, and the other to reflect the opposite. This is to identify whether accessibility improvement with prefectures with lower per-capita output is different to that with higher per-capita output.

$$\frac{1}{T}(\ln y_{it+T} - \ln y_{it}) = \alpha_1 + \beta_1 \ln y_{it} + \gamma_1 ACC^1 + \gamma_2 ACC^2 + \varepsilon_{it} \quad \ldots\ldots(7)$$

where,

$ACC^1 : airshare*(\ln y_{it} - \ln y_{jt}) * DUM_1 / (GV_{ijt+T} / GV_{ijt})$

DUM_1: 1 when $\ln y_{it} > \ln y_{jt}$, 0 when $\ln y_{it} < \ln y_{jt}$

$ACC^2 : airshare*(\ln y_{jt} - \ln y_{it}) * DUM_2 / (GV_{ijt+T} / GV_{ijt})$

DUM_2 :1 when $\ln y_{it} < \ln y_{jt}$, 0 when $\ln y_{it} > \ln y_{jt}$

Instrument variables for Barro regression were set as follows:

1) Natural log of GDP in origin prefecture
2) Natural log of GDP in destination prefecture
3) Air transport accessibility between origin and destination prefectures in 1995
4) Air transport accessibility between origin and destination prefectures in 2000
5) Population of origin prefecture
6) Share of agricultural output in origin prefecture

Table 3　Barro Regression Estimates (n=1410)

	C	$\ln(Yit / Lit)$	ACC^0	ACC^1	ACC^2	
Parameters for Equation 6 t statistics	.104403 6.60019**	-.584891E-02 -5.66236**	.031778 7.33908 **	-	-	R^2: .034019
Parameters for Equation 7 t statistics	.197074 5.71636**	-.011908 -5.28455**	- -	.053532 6.31782 **	.035516 7.07183 **	R^2: .030263

(** significant at 1% level)

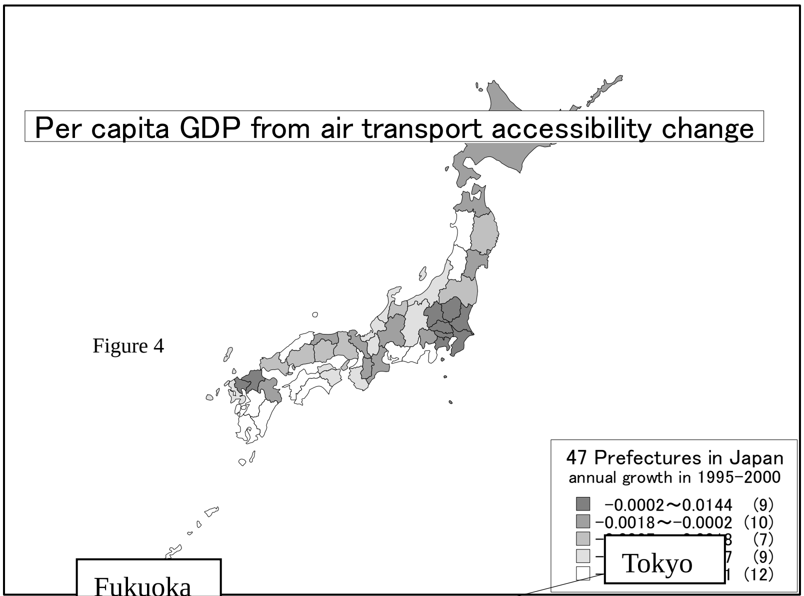


Figure 4

The result of Barro regression is listed in Table 3. As expected, initial level of per capita output is negative. Accessibility has significantly positive effect on growth. In equation 7, parameter for ACC^1 is higher than for ACC^2. This suggests that accessibility change is more sensitive to growth in a situation where the origin prefecture has a higher per-capita output than the destination prefecture. Since highly agglomerated metropolitan area, such as Tokyo, has higher per-capita output, improvement in air transport accessibility should have higher impact for these regions rather than rural areas. To identify aggregate effect of accessibility change per prefecture, estimated coefficient for equation 6 was used to calculate the per-capita output growth if air transport generalized cost in the accessibility index had not changed. The difference of per-capita output growth compared to that of actual accessibility is displayed in Figure 4. We could see that Tokyo metropolitan area and Fukuoka, center of Kyushu district, had considerable benefit from air transport accessibility improvement. It is striking, on the other hand, that other prefectures had negative impact on growth from air transport accessibility change between 1995 and 2000.

Conclusion

There was a missing link between air transport accessibility improvement and macro economic performance. This paper tries to fill the gap. Incorporating inter-regional accessibility index as an economic environment determinant in Cobb-Douglas production function and Barro regression framework, cross-sectional regression was undertaken using panel data of 47 prefectures in Japan. It was revealed that there has been significant productivity gain from improvement in air transport accessibility between 1995 and 2000 particularly in agglomerated areas such as the Tokyo metropolitan region. Further research is necessary, however, to understand more deeply the causal relationship between air transport accessibility, agglomeration and regional growth.

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