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Port Capital Formation and Economic Development in Japan: A Vector Autoregression Approach

by

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This paper analyzes the effects of port capital formation on GDP and private manufacturing investment in Japan for the time period of 1966 to 1997 using a vector autoregression model with port capital stock as an exogenous variable. Few past public capital studies specified impacts of transportation sectoral or subsectoral infrastructure on economic development. The VARX estimates and their impulse responses identify that both flow and stock effects of considerable magnitude accrue from port capital stock development to Japanese economy, which is heavily trade-oriented. An increase of 100 billion yen in port capital stock would increase accumulated GDP by 1,500 billion yen over eight years after the injection.

I. INTRODUCTION

The effectiveness of social capital formation for economic development is the major concern for policy makers in many countries. Japan lagged behind most western countries in her accumulation of social capital until the World War Ⅱ. Since then, social capital formation has been one of the most important policy issues and every year huge amount of funds have been invested during and after the era of rapid economic development of 1960s. While accumulated social capital plays an important role in supporting private productive activities as the stock effect, it is also believed by many Japanese policy makers that public investment boosts the economy in the short run as the flow effect.

The public work-related expenditures in the central governmental budget, which include typical infrastructure development such as road, river improvement, afforestation, port, sewage and park, amounted to 9.4 trillion yen in 2001, and are equivalent to 11.4% of the total general account budget. The Japanese government has been carrying out the Public Investment Basic Plan since 1995, which defines the guidelines for steady formation of social capital towards the new century. A total public investment of 630 trillion yen is planned from FY1995 to 2004. The total amount of outstanding government bonds at the end of FY2001 is estimated to be 389 trillion yen, 10.6% of which is construction bonds. It is important in this context that public investment is managed carefully.

The focus of public capital formation in this paper is on port. Port infrastructure is indispensable for Japan because geographically Japan is an island and economy is heavily trade-oriented. Japan's port capital stock is around 20 trillion yen as of 1993, which is equivalent to 0.14% of total public capital stock, and is one seventh of road capital stock. Port sector has a share of 0.24% in GDP and a share of 0.09% in employment. Port sector is relatively labor-intensive and its factor income constitutes 65% of the sectoral GDP, 82% of which accrues to labor income. Ministry of Land, Infrastructure and Transport is now completing the implementation of the 9th Seven-year Port Development Plan (1996-2002). It is of great concern to analyze from a macroeconomic point of view whether port development would assist in recovering Japanese economy.

Literature

Aschauer (1989a, b) suggests, by using a production function approach, that public capital in the U.S. significantly supports private production and contributes to its economic growth. Since then, there are a large number of empirical studies that estimate effects of public capital formation on economic growth, and early aggregate time series studies estimated highly the contribution of public capital to economic development. Gillen (1996) and Nijkamp and Poot (forthcoming) review most of them (studies of 1989-1993 are covered by Gillen, and 1983-1998 by Nijkamp and Poot). Many of the literatures follow the production function approach (see Gillen (1996), p.47), which regards social capital as a production input factor. Gillen then finds, "The statistical evidence is that core (e.g. highways) public capital is more significantly related to output growth and productivity." (p.48) A series of studies, based on this view, estimated cost or profit functions of private sector or specific industries to estimate shadow values of public capital (see Gillen, pp. 52-53). Gillen concludes, "The results of cost function studies indicate that in the majority of (U.S.) states the return of private capital exceeds that to public capital." (p.56)

Nijkamp and Poot (forthcoming) review 93 published studies on the link between government fiscal policy and economic growth, and confirmed the positive impact of education and infrastructure on growth. Out of the 39 fiscal policy studies on infrastructure, 72% concluded positive impact (see Nijkamp and Poot, Table 3). They, however, conclude, "The confirmation of the positive impact of education and infrastructure on growth derived from macroeconometric research does not provide much guidance for education or infrastructure policy, and research in this area will need to be complemented by appropriate micro level studies." (Nijkamp and Poot, Section 7)

Focus

We insist that the study disaggregation should take place not only in terms of study area, i.e., into regional contexts, but also in terms of infrastructure sector or subsector to offer useful policy implications. Public capital in most studies includes not only transportation but also communications, public utilities, sewage, park, and others, and surprisingly, transportation sector is seldom of clear study focus. Further aggregation into transportation modal subsectors such as road, railway, port or airport are more difficult. This is presumably due to availability problems of transportation sectoral and subsectoral stock data. Even if data were available in the production function approach, the function needs to incorporate all sectoral public capital, and doing so econometrically in a nested form usually causes multicollinearity. Also, a single transportation mode is not expected to bring sufficiently strong impacts on many national economies. For these reasons, Raj (1996) which dealt with U.S. highways is one of the very few examples, if not the only one. This study has overcome these difficulties in focusing on port infrastructure, and is another valuable case study, and should be the first one in port subsector.

We analyze effects of port capital formation in Japan on GDP of manufacturing and other sectors and on private investment of manufacturing sector in a multivariate time-series framework. We have, for the above stated reasons, chosen a vector autoregression model with exogenous variables (VARX model) instead of the production function approach. Vector autoregression (VAR) models are sometimes used to study effects of infrastructure development. Pereira and Sagales (1999), Sturm et al. (1999), and Otto and Voss (1996) applied VAR models for their studies of Spain, Netherlands, and Australia, respectively. However, they again deal with overall public capital instead of transportation capital, and public capital is treated as an endogenous variable. We, on the other hand, apply a VARX model with port capital as an exogenous variable by regarding it as a policy control variable in view of Japan's subsectoral allocation context of public capital funds, and simulated economic impacts due to port policy changes.

II. Model Specification

A VAR model can be structured as

$$Y_t = \sum_{s=1}^{L} A(s) Y_{t-s} + U_t \qquad (1)$$

where Y_t is an n-dimensional, stationary, time-series vector, $A(s)$ is an $(n \times n)$ coefficient matrix, s is the number of lag with the maximum value of L and U_t is an n-dimensional white noise vector term independent of Y_{t-1}, Y_{t-2}, $\cdots$. Eq. (1) assumes that Y_t is a function of only endogenous variables of previous time periods.

The VARX model, which is an extension of the VAR model, relaxes the assumption regarding Y_t, and Y_t now depends on exogenous variables of previous time periods as well. The model therefore is modified as

$$Y_t = \sum_{s=1}^{L} A(s) Y_{t-s} + \sum_{s=1}^{L} B(s) X_{t-s} + U_t \qquad (2)$$

where $B(s)$ is the coefficient matrix for exogenous variables X_{t-s}.

It is assumed that the economic production process in Japan follows Eq. (2) involving port capital stock as an exogenous variable. Using estimated Eq. (2), we analyze the effects of the port capital formation on GDP and private manufacturing investment in Japan.

Data Description

The endogenous variables in our model are GDP, private capital stock in manufacturing sector, and output deflator in transport and communication sector. The GDP data is divided into manufacturing sector (includes construction sector), which is influenced by port development, and the remaining non-manufacturing sector. Transport deflator represents a user cost indicator of transport sector with the base year of 1990. The exogenous variables are limited only to port capital stock in our model to discuss port capital formation policy.

The data of GDP and transport deflator are collected from "Annual Report on National Accounts". Private capital stock data is from "Annual Report on Capital Stock of Private Enterprise". These statistics are compiled by the Economic and Social Research Institute, Cabinet Office, Government of Japan. Port capital stock was obtained from Ports and Harbors Bureau of Ministry of Land, Infrastructure and Transport. The common time period for which these statistics are available is from 1966 to 1997. Except for transport deflator, all other variables are in trillion yen in 1990 real price.

Time Series Property

Time-series analysis requires that variables are stationary, and the Augmented Dickey-Fuller (ADF) test is conducted to test for stationarity. The test indicates that the null hypothesis of unit root on the level data of port capital stock cannot be rejected. However, ADF test on logarithmic form (denoted as LNKP in Table 1) suggests that the null of unit root can be rejected at 5% significance level with or without trend variable.

Stationarity for the endogenous variables is also checked by ADF test in association with a constant term. The null of a unit root on manufacturing GDP in its logarithmic form (LNMNFT) can be rejected at 5% level in with-trend case, and at 10% level in without-trend case. The null for non-manufacturing GDP and transport deflator, both in their logarithmic form (LNOTHE and LNDFLT, respectively) in without-trend case, can be rejected at 5% level. The null of net investment of private capital stock (PRIIV), in its natural form, can be rejected at 5% level in with-trend case. Economic time series data often requires transformation to differential form to become stationary or the use of cointegration techniques for data remaining as non-stationary. However, this analysis does not need differential transformation to make the data stationary.

Table 1. ADF tests for the variables

	ADF t-value	Lag	Trend (t-value)
LNKP	−3.42**	6	0.0122 (3.38)
	−3.24**	2	None (−)
LNMNFT	−3.75**	3	0.0169 (3.54)
	−2.62*	1	None (−)
LNOTHE	−2.89	1	0.0071 (2.42)
	−2.87**	1	None (−)
LNDFLT	−1.91	1	0.00099 (0.81)
	−2.95**	8	None (−)
PRIIV	−3.93**	1	0.127 (2.84)
	−2.46	1	None (−)

* and ** indicate significant at 10% and 5% levels, respectively.

III. ESTIMATES

The VARX model was specified to choose the optimal lag structure by minimizing the Schwarz Box Information Criterion (BIC). Deterministic components are considered if statistically significant. The estimated VARX equations are shown in Table 2. In this specification, transport deflator is not explained by any other endogenous variables in terms of Granger causality test. Net private investment is not explained by manufacturing GDP. Interestingly, all endogenous variables include port capital stock as an independent variable.

We apply impulse response functions to simulate the effect on each endogenous variable of a shock of increasing port capital stock by 100 billion yen, evaluated in 1990 price, at the time of zero. Figures 1 and 2 delineate the results.

Table 2. VARX estimation results

Dep. Var.	LNMNFT		LNOTHE		LNDFLT		PRIIV	
Ind. Var. (lag)	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
LNMNFT(-1)								
LNMNFT(-2)	-0.200	(-1.82)*						
LNMNFT(-3)			-0.358	(-2.66)**				
LNOTHE(-1)	0.994	(9.35)***	0.714	(7.43)***			52.585	(2.95)***
LNOTHE(-2)								
LNOTHE(-3)								
LNDFLT(-1)			-0.185	(-2.95)***	1.296	(36.79)***	-5.156	(-1.87)**
LNDFLT(-2)	-0.124	(-1.74)*						
LNDFLT(-3)					-0.313	(-8.07)***		
PRIIV(-1)	0.009	(5.66)***					0.932	(5.86)***
PRIIV(-2)							-0.704	(-5.08)***
PRIIV(-3)			0.004	(2.03)*				
LNKP(-1)	1.615	(3.58)***	0.994	(2.73)**	-0.803	(-2.96)***	-16.44	(-2.28)**
LNKP(-2)	-1.760	(-2.27)**	-2.031	(-3.61)***	2.387	(4.78)***		
LNKP(-3)	0.634	(1.27)	1.682	(4.29)***	-1.562	(-6.24)***		
T	-0.006	(-1.77)*					-0.76	(-1.88)*
C			2.672	(3.48)***			-190.954	(-2.79)**
Adj R^2	0.997		0.998		0.998		0.887	
D.W.	1.659		2.252		2.248		2.290	

*, ** and *** indicate significant at 10%, 5% and 1% levels, respectively.

T and C are trend and constant terms, respectively.

Figure 1. Responses on GDP and net private investment

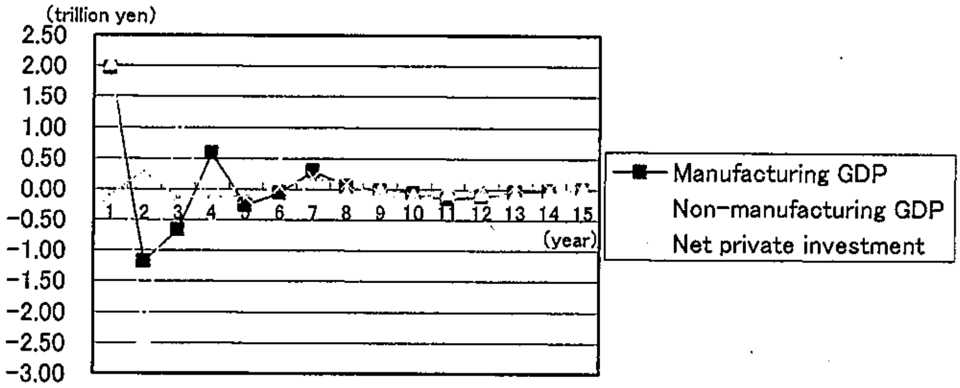
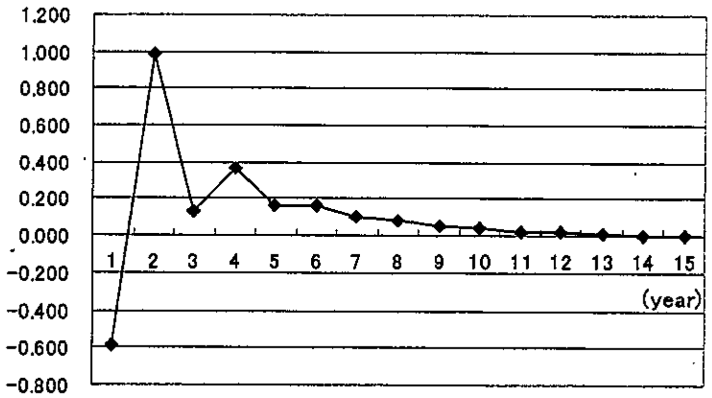


Figure 2. Responses on transport deflator



Implications

An additional port capital stock of 100 billion yen given in Year 0 increases GDP of both manufacturing and non-manufacturing in Year 1 considerably due to the flow effect of port capital investment. Moreover, a fall in transport deflator in Year 1, as a result of user transport cost reduction caused by the initial port capital injection, generates an increase in the value added and accompanying income effect. These are the mechanisms of strengthening GDP in Year 1. Net private investment is presumably crowded out in the money market by the government expenditure on port and other related capital stock.

An increase in GDP in Year 1, in turn, derives additional transport demand, and pushes up transport deflator in Year 2. Increased transport and other user costs seem to be a cause for reduced GDP in the same year. On the other hand, net private investment in Year 2 increases stimulated by the earlier GDP growth.

In response to the reduced transport demand due to the GDP decrease in Year 2 and to transport cost relief by the original port capital formation, transport deflator decreases from Year 2 to 3. Such transport and other user cost reductions gradually recover GDP after years. Net private investment decreases again in response to the transport deflator rise and GDP reduction in Year 2. The impacts on the endogenous variables are entwined somewhat cyclically over the following years, and finally the effects of the initial port capital stock injection converge.

The impulse analysis simulates that an additional port capital stock of 100 billion yen would increase the GDP of all sectors by about 1,500 billion yen in 1990 price cumulative over eight years after the injection. Up and down effects on private investment by the port capital shock more or less cancel out each other. It is concluded that the port sector in Japan did not show any indications of over-capital investment and contributed to Japan's economic growth.

IV. SUMMARY AND CONCLUSION

This paper analyzes the effects of port capital formation on GDP as well as private sector investment using a VARX approach. The VARX estimates and their impulse responses indicate that an additional port capital investment of 100 billion yen would increase GDP by approximately 1,500 billion. Both flow and stock effects on GDP have been associated with the port capital formation in Japan.

Japan's port capital stock still appears to be under-invested as compared to other subsectoral social capital stock, and maintains high marginal productivity. Reinforcement of Port capital stock is possibly an effective policy alternative for revitalization of trade-oriented Japanese economy. By disaggregating public capital into transportation subsector in the analysis, useful policy implications are obtainable. However, since the study time period contains the era of Japan's rapid economic growth of 1960s, further analysis of the most recent trends may be necessary for more detailed policy recommendations.

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