Efficiency and Network Expansion in the Telecommunications Sector: A Study of the Asian Experience

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Abstract: *This paper considers the potential impact of privatization and the existence of an autonomous regulatory body on outcomes in the telecommunications sector. Previous studies suggest that privatization leads to greater efficiency and network expansion; however, the evidence is not conclusive and some authors have found no positive results from privatization. This paper looks specifically at the Asia-Pacific region using a small panel data set. There do not appear to be any significant improvements in industry outcomes related to privatization.*

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I. INTRODUCTION

For various reasons the telecommunications industry attracts considerable attention from economists and policy makers alike. A high degree of asset specificity and the importance of network externalities in this market created high barriers to entry under the fixed line technology. Recent technological advances have helped to transform the industry in many countries. However, the precise policies in a given country can have a significant impact on how these technological changes are realized. For example, in some countries the government may rely on a state owned telecommunications service provider as a source of revenue and therefore be reluctant to implement policies which might reduce these revenues in favor of market competition and lower prices. The impact of such policies reach further than the telecommunications market alone when we recognize the role of such technologies on productivity (see for example Bernanke, 2005). Essentially, telecommunications are part of the information and communication technologies which serve to increase productivity in various sectors of the economy.

Some studies of the telecommunications industry then focus on the impact of various state controlled variables on industry outcomes. Other studies attempt to uncover the process by which countries make transitions in terms of their policies toward the industry. In this paper we make a modest contribution to the body of work which examines the impact of state controlled variables on industry outcomes such as network expansion and efficiency. We do this by focusing attention on the evidence from a group of countries in the Asia-Pacific region. When we use the term network expansion we mean the number of telephone line per 1000 residents and we sometimes refer to this as

"teledensity". When we use the term efficiency we mean the number of telephone lines per full time employee in the telecommunications sector.

One of the more prominent state controlled variables is the degree to which the assets in the telecommunications industry are publicly versus privately held. The impact of privatized industry assets on efficiency and network expansion is not readily apparent. That is, there are arguments that privatization of assets could either increase or decrease efficiency and/or network expansion. For example, privatization of assets could decrease efficiency if there is a lack of competition in the market and firms with market power fail to take advantage of least-cost technologies or otherwise engage in inefficient practices (see for example Leibenstein, 1966). On the other hand, private institutions may face greater incentives from shareholders to lower costs through technical efficiency. Similarly, with network penetration, state owned organizations may pursue goals of greater network expansion when the government perceives that there are positive externalities associated with the use of telecommunications services. Alternatively, the lack of market incentives and the existence of government budget constraints may prevent the state from engaging in profitable network expansion. Megginson and Netter (2001) provide a review of the impact of privatization in a wide range of markets, not solely the telecommunications industry.

Another variable that appears relevant in the telecommunications industry is the existence of separate and autonomous regulatory agency for the telecommunications sector. For example, in the United States the regulatory body is the Federal

Communications Commission which although subject to Congressional oversight is nonetheless a separate regulatory agency. When the regulatory agency lacks any degree of independence industry regulations may suffer from conflicts of interest within the government. For example, immediate political interests may induce actions on the part of regulators that neither enhance efficiency nor promote long-term industry development. Previous studies have examined both the impact of privatization and the existence of an autonomous regulatory body; we add to this body of work with a focus on the experience in Asia.

Previous studies vary in terms of both their breadth and estimation techniques. Some studies examine a broad cross section of countries. For example, Ros (1999) considers a sample of 110 countries and finds evidence that privatization is positively related to network expansion. His study uses panel data from 1986-1995. Another broad cross section study is that of Cox and Lee (2003). They look at a sample of 111 countries and find that privatization is positively related to both network expansion and efficiency. However, they find no statistically significant relationship between the existence of separate and autonomous regulatory body and either network expansion or efficiency.

Other studies tend to focus on a narrower group of countries or even the case of one particular country. For example, Wallsten (2001) focuses on a group of African and Latin American nations and finds a negative relationship between the regulatory agency and network expansion. Wallsten does find that competition positively impacts network expansion. Ros and Banerjee (2000) consider a small sample of Latin American countries

and find that privatization is positively related to both network expansion and efficiency. Gutierrez (2003) studies a group of Latin American and Caribbean countries. He finds that regulatory structure is an important determinant of network expansion. He also finds that privatization and competition are positively related to network expansion. Similarly, Ramamurti (1996) studies the telecommunications experience in Latin America. His study focuses on privatization and finds positive effects of privatization on industry outcomes. Finally, Boylaud and Nicoletti (2000) examine a sample of 23 countries and find that competition increases productivity. However, they find that privatization has no clear impact on productivity. The body of evidence is thus unclear on some points.

A limited number of studies focus on a single country. The experience of the U.S. in the telecommunications market is unique in that it is the birth place of the industry and the fact that industry assets were privately held from its inception. Noll and Owen (1994) discuss the possibility of using regulation for anticompetitive purposes. McMaster (2002) provides and overview of the industry in the U.S. with a discussion of the effects of competition and network access. Aside from the U.S. market Boles de Boer and Evans (1996) provide a study of the industry in New Zealand. They find that privatization leads to declining prices and improved services for New Zealand.

The level of privatization and telecom sector performance observed in Asian countries vary widely depending on the level of their overall economic development. For instance, low level of teledensity and poor quality of telecom services have been typical of the less developed countries such as Bangladesh, India, Pakistan, and Sri Lanka. Lee

(2003) argues that relatively poor performance of the telecom sector in those countries is not only due to underinvestment in the sector which results from governments' inability to raise necessary funds to finance construction of infrastructure and equipment procurement but also partly due to low priority given to the telecom sector by the government. In a similar study on telecom sector performance in Asia, Chowdary (1997) observes that the governments with lack of capital in the region typically responded to the problem by allowing a limited participation of private sector investment in the telecom sector while seeking for soft loans from developed countries to protect political and financial stake in the sector of the state.

Our contribution to this body of work is to examine the industry in the Asia-Pacific region. Previous authors have noted that regional differences suggest some value to isolating a particular subset of countries in a geographic region. Below we describe the data and our estimation methods. Later we provide the empirical results and discuss our findings in the conclusion.

II. DATA AND ESTIMATION METHODS

The data on various country characteristics were obtained from the World Development Indicators (1999). The information on the organizational structure of telecom regulatory body and the ownership status of public telecom service providers are from Trends in Telecommunication Reform: Country Profiles 2002 CD-ROM from the International Telecommunication Union. However, due to the lack of information on

private assets as the percent of total assets of state-owned telecom service providers, we use a dummy variable for privatization. The data are for a group of 15 countries for the years 1992-1998. The countries are: Australia, Bangladesh, Bhutan, China, India, Japan, Cambodia, South Korea, Sri Lanka, Mongolia, Malaysia, Nepal, New Zealand, Pakistan, and Thailand. We selected these countries and this time period because of data availability that allowed for the largest balanced panel.

The data consist of variable for state controls or industry characteristics and industry outcomes as well as other country specific characteristics. The industry outcomes that we observe are EFFICIENCY which is the number of telephone lines per full time employee in the telecommunications sector and TELEDENSITY which is the number of telephone line per 1000 residents. The state controlled characteristics that we observe are: PRIVATE, a 1 if the country has privatized telecommunications assets and 0 otherwise; SEPREG, a 1 if the country has a separate and autonomous regulatory body for the telecommunications sector and a 0 otherwise. Other variables control for cost and demand differences across countries; these include: LAGPCGDP, the lagged value of per capita gross domestic product (in $1000) which is a demand shifter; OPENNESS, the total value of imports and exports as a percentage of gross domestic product which is a measure of global contact and interdependence; lastly, POPDEN is the urban population density which is a cost shifter.

We estimate various regression parameters using the industry outcomes as the dependent variables and the country characteristics as independent variables. Initially we

estimate parameters using ordinary least squares. However, in the panel data setting it is possible that there are varying country effects. Accordingly, we estimate the relationship using the least squares dummy variable (LSDV) method explained in Greene (1997). In essence the LSDV estimators are OLS estimators where there are fixed effects or in other words a dummy variable for the country effects.

Lastly, because of the time series component inherent in the panel data we address the potential problem of autocorrelation by obtaining full generalized least squares (FGLS) estimates (the FGLS method is also known as the Prais-Winsten method). For each country we estimate the correlation among error terms as an AR(1) process. We obtain these estimates using the error terms obtained from the LSDV procedure. We then use these correlations to construct a weighting matrix and obtain the FGLS estimates. Specifically, let ρ_i be the estimated error correlation for country *i,* then let $\mathbf{W}_i$ be a symmetric matrix with 1s along the diagonal and the upper off diagonal element in row *k* and column *j* equal to $x_{kj}= (\rho_i)^{j-k}$. Then let **W** be the block diagonal matrix with the $\mathbf{W}_i$ matrices along the diagonal. Conceptually, one then finds a matrix **H** such that

$$\mathbf{HWH}^{\mathrm{T}}=\mathbf{I},$$

where $\mathbf{H}^{\mathrm{T}}$ denotes the transpose of **H** and **I** is the identity matrix. Then one uses **H** to weight the data matrices **Y** and **X** which are the matrices of the dependent and independent variables respectively. Ultimately, however, the FGLS estimator is just

$$\mathbf{B}_{\mathrm{FGLS}}=(\mathbf{X}^{\mathrm{T}}\mathbf{W}^{-1}\mathbf{X})^{-1}\ \mathbf{X}^{\mathrm{T}}\mathbf{W}^{-1}\mathbf{Y}.$$

The interested reader can find additional details in Greene (1997) or Pindyck and Rubinfeld (1991).

III. EMPIRICAL RESULTS

In this section we report the results of the OLS, LSDV, and FGLS regressions. We also conduct some diagnostics as suggested by Chatterjee and Hadi (1988). For the regressions concerning TELEDENSITY we use two separate functional forms. In table 1 we report results from the linear functional form while in table 2 we report results from a semi-log functional form. In part we report the results of the semi-log forms to be consistent with other studies.

(Table 1 about here)

The OLS estimates from table 1 show that neither PRIVATE nor SEPREG have a statistically significant impact on TELEDENSITY. This is also true for the LSDV and FGLS estimates. An *F* test of the LSDV restrictions has 14 numerator degrees of freedom and 85 denominator degrees of freedom. The test statistic is 432 which exceeds the .01 level critical value of approximately 2.3 and we reject the hypothesis that there are no country effects.[1] Not surprisingly, the estimated coefficients on LAGPCGDP and POPDEN are both positive and statistically significant. However, only the error terms from the LSDV do not violate the normality assumption. The test statistics for the OLS and LSDV regression presented in table 1 and the subsequent tables obtained using White's heteroskedasticy consistent variance covariance matrix. The test statistics for the FGLS regressions are obtained using the variance covariance matrix,

[1] Test of LSDV restrictions: $F(n-1, nT-n-K)=[(R^2_{lsdv}- R^2_{ols})/(n-1)]/[(1- R^2_{lsdv})/(nT-n-K)]$, where n=15 (the number of countries), T=7 (the number of years), and K=5 (the number of covariates).

$$(\mathbf{X}^T\mathbf{W}^{-1}\mathbf{X})^{-1}\ \mathbf{X}^T\mathbf{D}\mathbf{X}\ (\mathbf{X}^T\mathbf{W}^{-1}\mathbf{X})^{-1},$$

where **D** is a diagonal matrix with element $d_i=(u_i)^2/(w_i)^2$, where u_i is the ith error and w_i is the ith diagonal element of **W**. (See Greene, 1997 page 569, for the properties of this estimator).

(Table 2 about here)

The OLS estimates from table 2 show that neither PRIVATE nor SEPREG have a statistically significant impact on the log of TELEDENSITY. This is also true for the LSDV and FGLS estimates. The *F* test statistic for the LSDV restrictions is 84 so that we again reject the hypothesis that there are no country effects. One interesting difference between the results from tables 1 and 2 is that the estimated coefficient on LAGPCGDP for the semi-log LSDV regression is negative and statistically significant.

The OLS estimates from table 3 show that PRIVATE has a positive and statistically significant impact on EFFICIENCY while SEPREG has a negative and statistically significant impact on EFFICIENCY. However, the *F* test statistic for the LSDV restrictions is 33 so that we again reject the hypothesis that there are no country effects. Then, the LSDV and FGLS estimates show that PRIVATE has a negative and statistically significant impact on EFFICIENCY. However, we note that the error terms do not satisfy the normality assumption and hypothesis test may not be valid. LAGPCGDP and POPDEN both have positive and statistically significant impacts on EFFICIENCY.

(Table 3 about here)

In table 4 we see that the OLS estimates for the coefficient on PRIVATE is positive but not statistically significant (although nearly so). The estimated coefficient on SEPREG is negative and statistically significant. However, the *F* test statistic for the LSDV restrictions is 55 and we reject the hypothesis that there are no country effects. The results from the LSDV and FGLS regressions suggest that neither PRIVATE nor SEPREG has an impact on the log of EFFICIENCY. In this case the error terms from the LSDV regression satisfy the normality assumption and we are inclined to believe that the semi-log functional form is a better description of the true relationship between EFFICIENCY and the other variables. POPDEN appears to be positively and statistically significantly related to the log of EFFICINECY while on the whole there is not strong evidence that LAGPCGDP has any impact.

(Table 4 about here)

IV. CONCLUSION

In summary we find that neither the existence of privatized assets nor the establishment of an autonomous regulatory body has any impact on network expansion in the Asian region. Although some of our results suggest that privatization may have a negative impact on efficiency we are more inclined to believe the results that

privatization does not have a statistically significant impact on efficiency; the same is true for the existence of an autonomous regulatory body. While the bulk of the current evidence suggests that privatization has a positive impact on industry outcomes, our findings are more consistent with those of Boylaud and Nicoletti (2000) who find that privatization does not have a clear relationship to industry outcomes.

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Table 1
REGRESSION RESULTS FOR TELEDENSITY

COVARAITE	OLS	LSDV	FGLS
INTERCEPT	-70.51*	-681.62*	-651.03*
	(-5.82)	(-5.15)	(-4.56)
PRIVATE	-21.04	-3.47	-2.94
	(-1.29)	(-1.58)	(-1.25)
SEPREG	-17.01	-4.82	-2.08
	(-1.24)	(-1.50)	(-1.44)
LAGPCGDP	7.57*	16.41*	16.93*
	(7.13)	(12.91)	(12.19)
OPENNESS	-.09	-.05	-.00
	(-.68)	(-.69)	(-.10)
POPDEN	4.50*	10.09*	9.55*
	(9.84)	(6.25)	(5.58)
N	105	105	105
R^2	.9133	.9988	.9986

Robust t-statistics are in parentheses. * denotes statistical significance at the .01 level or better.

Table 2
REGRESSION RESULTS FOR LOG OF TELEDENSITY

COVARAITE	OLS	LSDV	FGLS
INTERCEPT	0.59*	-15.14*	-31.98*
	(2.68)	(-3.71)	(-22.94)
PRIVATE	0.17	0.10	-.17
	(1.03)	(0.88)	(-1.23)
SEPREG	0.03	-.09	0.05
	(0.22)	(-.57)	(0.41)
LAGPCGDP	0.05*	-.08**	0.54*
	(5.55)	(-2.36)	(31.35)
OPENNESS	0.01*	0.00	-.00
	(4.52)	(0.31)	(-.58)
POPDEN	0.05*	0.27*	0.32*
	(11.39)	(5.35)	(26.53)
N	105	105	105
R^2	.8055	.9869	.9989

Robust t-statistics are in parentheses. * denotes statistical significance at the .01 level or better, ** denotes statistical significance at the .05 level.

Table 3
REGRESSION RESULTS FOR EFFICIENCY

COVARAITE	OLS	LSDV	FGLS
INTERCEPT	13.11	-1518.81*	-1430.13*
	(1.32)	(-3.84)	(-3.53)
PRIVATE	31.37**	-19.64*	-11.65**
	(2.41)	(-2.69)	(-2.02)
SEPREG	-57.98*	4.09	0.15
	(-5.12)	(0.54)	(0.02)
LAGPCGDP	4.02*	18.27*	20.74*
	(4.75)	(3.35)	(3.63)
OPENNESS	0.07	-.25	-.18
	(0.52)	(-1.43)	(-1.52)
POPDEN	1.19*	15.07*	13.42*
	(3.20)	(3.11)	(2.76)
N	105	105	105
R^2	.7425	.9602	.9174

Robust t-statistics are in parentheses. * denotes statistical significance at the .01 level or better, ** denotes statistical significance at the .05 level.

Table 4
REGRESSION RESULTS FOR LOG OF EFFICIENCY

COVARAITE	OLS	LSDV	FGLS
INTERCEPT	2.82*	-17.77*	-55.74*
	(17.41)	(-3.98)	(-172.53)
PRIVATE	0.33	-.00	-.22
	(1.92)	(-.05)	(-1.37)
SEPREG	-.36**	0.02	-.12
	(-2.59)	(0.16)	(-.74)
LAGPCGDP	0.04*	-.03	-.04*
	(3.99)	(-.66)	(-4.04)
OPENNESS	0.00	-.00	-0.73*
	(1.07)	(-.48)	(159.84)
POPDEN	0.02*	0.27*	42.66*
	(3.68)	(4.97)	(63.56)
N	105	105	105
R^2	.6242	.9626	.9974

Robust t-statistics are in parentheses. * denotes statistical significance at the .01 level or better, ** denotes statistical significance at the .05 level.