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The Effect of Endogenous Regulation on Telecommunications Expansion and Efficiency in Latin America*

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Abstract
I examine the effect of reform on telecom performance using a second-generation regulatory framework index and panel data techniques to test how regulatory governance affected sector performance in 22 Latin American countries during the period 1980–1997. Sound regulatory governance in telecommunications has a positive impact on network expansion and efficiency, in both the static and dynamic specifications. Openness of markets to competition and divestment of former state-owned telco operators also contributed positively to better sector performance. The dynamic specification shows that past performance has its own strong effect on present (and perhaps future) performance.

1. Introduction

Using a sample of 22 Latin American countries during the period 1980–1997, I investigate the effect a specialized regulatory body has on telecommunications sector performance. The focus is on whether having a better or more developed regulatory framework has been a major factor in main lines deployment and telecommunications efficiency. To study the roles of various factors, this research utilizes a ''second-generation'' index of regulatory framework, proxy variables for privatization and liberalization and some control variables that allow for country- and time-specific effects. Additionally, the sample is split to consider 12 countries with a lower level of development and endogenize some of the main telecom reform variables. Lastly, I use dynamic panel data techniques to test the hypothesis that a clear regulatory framework (as measured by the new index) improves sector performance.

I find that better regulatory frameworks do impact telecommunications efficiency and

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the level of network deployment positively, in both the static and dynamic specifications. Those countries where regulatory reform has been furthered had growing levels of efficiency and main lines per 100 inhabitants. However, the effect of regulatory reform is a little lower for the sample of countries with lower income. Also, when time effects are not included, those countries that allowed competition in basic telecommunications services had more main lines per 100 inhabitants and better efficiency. Privatization also contributed to an expanded main line network.

This study sheds light on the importance of a sound regulatory environment that opens markets to competition and supports privatization. From the standpoint of econometric modeling, the study underscores the usefulness of a dynamic framework when analyzing the performance of telecommunications sectors across countries, over time. The first section reviews some related empirical studies of telecommunications reform and performance. The second presents an econometric analysis, with a detailed explanation of the main results found for a sample of Latin American and Caribbean countries. The paper concludes with some general observations on the role of regulation in promoting telecommunications expansion and efficiency.

2. Empirical Studies on Telecommunications Reform

A major task of Latin American governments has been to signal the credibility of their telecommunications reform. Without credibility, the expectation of future policy reversal might become a self-fulfilling prophecy, defeating the purpose of the reform. From the point of view of private investors, long-term investments in telecommunications carry the risk of expropriation and of having investments taken hostage (Williamson 1983) in terms of government's ability to force utilities to charge unprofitable rates for their services.

The degree of opportunistic behavior varies from country to country, and one should expect opportunistic behavior to be greater when there is not a sound institutional and regulatory environment. Thus, governments that want to encourage private investment must create an institutional arrangement that limits their own ability to behave opportunistically once (private) telecom operators undertake their investments. Yet, creation of a regulatory body brings new questions concerned with accountability and degree of autonomy.

Telecommunications reform in Latin America has seldom been studied. Most empirical studies focus only on the few Latin American countries that have privatized (totally or partially) their former public telecom operators.[1] Some recent econometric studies have tried to explain partial telecommunications reforms or the effects of political and

1 The more outstanding studies include (1) Ramamurti (1996), who analyzes the privatization process in Argentina, Jamaica, Mexico and Venezuela, (2) Molano (1997), who studies the effects of micro and macro variables on telecommunications in the Southern Cone of Latin America (Argentina, Brazil, Chile and Uruguay), (3) Adam et al. (1992), who briefly review the cases of Jamaica and Trinidad and Tobago, (4) Levy and Spiller (1996), who thoroughly study the regulatory process in Argentina, Chile, and Jamaica, (5) the five studies on Latin America in a book edited by Wellenius and Stern (1994), (6) Petrazzini (1995), who analyzes the cases of Argentina and Mexico, and (7) Galal et al. (1994), who

institutional variables on network deployment. Henisz and Zelner (2001) explored how political institutions, measured by an index of checks and balances, affect the long-run level of penetration of telecommunications infrastructure in 147 countries during 1960–1994. Their variable indicating political constraint showed a strong and positive relationship with growth of main lines per 100 inhabitants. Their study highlights the importance of the macro-polity for promoting steady and strong incentives to private investors in a sector where opportunistic behavior may be expected.

Gutierrez and Berg (2000) studied the effects of telecommunications regulation and political variables on network expansion in 20 Latin American countries, but the study was limited to a short time sample (1986, 1990, 1995) and to the effects of the overall polity on telecommunications performance. Using a two-stage least squares (2SLS), they found that political and institutional variables help explain the level of network expansion. Moreover, they constructed and tested the first index of regulatory framework in telecommunications for the region.[2] The index was found to be positively associated with network deployment, which means that a better, specific regulatory environment leads to greater investments in telecommunications.

Ros (1999), in a study similar to this one, was the first econometric attempt to explain network deployment and telecommunications efficiency for a sample of 110 countries around the world. His main results are that ownership, a telecom reform variable, was positively related to the main lines variable and with its growth rate, but competition, his second reform variable, seemed to have no effect on network expansion. The work of Ros clarified some effects of telecommunications reform but does not explain at all the effect that regulation may have had on telecommunications performance. As he mentions,

> Regulation plays an important role that affects a firm's efficiency.... As such, it is important to attempt to control for the type of regulation that the newly privatized firms are exposed to.... While all these factors are important theoretical determinants of network expansion and efficiency, data constraints prevented them from being *formally modeled below. As a result, any conclusions obtained below must take this into account* (Ros 1999, 72, emphasis added).

Ros mixed developed and developing countries in his sample, which introduced a lot of heterogeneity and may have biased his results. Although he ran regressions for countries with GDP per capita below U.S. $10,000, this was unlikely to reduce the level of heterogeneity or the scope of his conclusions. One good aspect of Ros' research is that he endogeneized competition and privatization, so his results shed light on understanding telecom reform.

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examine the welfare effects associated with privatization of the telecom operators in Chile and Mexico. These studies and others helped with my earlier construction of an index of regulatory framework for 24 Latin American countries; see Gutierrez (2001).

2 That index has some shortcomings. The most important is that it was dichotomous, i.e., it took a value of 1 if the country satisfied some elements (degree of independence, enforcement and neutrality of the regulatory body) and zero otherwise. I have since addressed limitations of the index in Gutierrez (2002).

A paper by Ros and Banerjee (2000) looks at relationships between privatization and network expansion and efficiency for a sample of 23 Latin American countries during 1986–1995. Employing a cross-section/time-series data model, they found that privatization is positively related to both variables, although the effect is smaller than the one found by Ros (1999) for the worldwide sample of 110 countries.

Wallsten (2001) analyzed telecommunications reform for a sample of countries in Africa and Latin America, testing how and to what extent variables like privatization, competition, and regulation affected network expansion from 1984 to 1997. His main results were that competition impacts main line penetration positively, but that privatization is negatively associated (although not statistically significant). Regulation alone is negatively and significantly associated with network expansion. In his model, competition and privatization were interacted with the regulatory variable, and both of them affected the level of main line penetration positively.

Although, Wallsten's research is a good contribution to the study of telecommunications reform, it compares countries in very dissimilar areas. There is a lot of different institutional and cultural development that one needs to control for even within Latin America. Another problem is Wallsten's use of the number of cellular companies in a country to measure competition; in Latin America cellular operators in a region cannot *legally* provide telecommunications services other than in their own markets. A cellular user wanting to call to a different region has to use a long distance operator (or pay roaming services for calling a mobile user). Finally, Wallsten assumes that all telecommunications reform variables are exogenous, an unrealistic assumption.

Hamilton (2001) analyzes how specific institutional, political, and competitive factors affect performance of basic telephony in some African countries. Her main results show that a strong institutional framework can enhance investment in basic telecommunications and that higher income levels (measured by GDP per capita) lead to improved performance, although it is not so strong as found in other studies. Lastly, Hamilton found that more open markets for the provision of telecommunications improve access to telecommunications services.

3. Data Analysis

Latin America and the Caribbean are composed of more than 30 large and small countries with a wide variety of cultural, economic, institutional and political factors. In this analysis, I consider the telecommunications markets in 22 of these countries[3] during 1980–1997, using network deployment (main phone lines per 100 inhabitants) and efficiency (main phone lines per employee) as the two dependent variables. I consider three main aspects of telecommunications reform—privatization, competition and regulatory development—as explanatory variables.

3 The countries, in alphabetical order, are: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, the Dominican Republic, Suriname, Trinidad and Tobago, Uruguay and Venezuela.

OWNER measures the level of privatization, with a value of 1 when government divestment of former state-owned telco operators exceeds 50%, and zero otherwise. One would expect that privatization, on average, has a positive effect on network deployment. COMPET accounts for both allowing entry into basic telecommunications services (local and long distance) and the beginning of wireless telecommunications, either in large cities or throughout an entire country. I do not always have complete information about where mobile telephony was initially launched in each country, but assume nonetheless that wireless telephony is a competitive pressure for fixed local telephony. However, as Ros (1997) stresses, increased competition via fixed or mobile telephony can have ambiguous effects on network deployment, depending on whether the economies of scale are strong and on the kind of price regulation for telecom local and long distance services. If one adheres to the view that technological changes may have undermined the assumption of natural monopoly in telecommunications,[4] then it is reasonable to assume that, ''competition is likely to have positive effects on network expansion'' (Ros 1997, 72).

Network industries, including telecommunications, share three main characteristics. They have important economies of scale, their assets are highly specific and redeployable to other activities only at very high costs, and their services are considered necessary goods (Levy and Spiller 1994). These traits make utilities vulnerable to administrative expropriation and so explain the perceived need for a regulatory agency insulated from undue political pressures.

Levy and Spiller (1994, 1996) consider two dimensions of regulation: governance and incentives. Governance is determined basically by a country's institutional endowment, while incentives pertain to pricing, subsidies and other operating policies. I view regulatory governance as the key element in the creation of a regulatory framework for telecommunications since incentives improve sector performance only if strong regulatory governance in the form of checks and balances that limit executive and legislative discretion is present. My index does not address how the regulators regulate the firm. A more comprehensive index must take it into account, but detailed information is lacking or hard to find. Gutierrez (2002) addresses this issue exclusively.

Illustrating how regulatory governance has enhanced telecommunications in Latin American, the index might best be viewed as the set of minimum regulatory conditions needed for private investors to undertake telecom projects. Its main dimensions proxy elements that practitioners and experts in utilities have long considered vital: (1) the extent to which there exists separation between operating and regulatory activities, (2) the degree of regulatory governance in terms of freedom from political and industry interference, clarity of regulatory functions and objectives, accountability and transparency regarding regulatory decisions, and (3) the kind of legal mandate that created the regulatory entity;

4 According to Spulber (1995, 35), ''As a consequence of technological change and industry development . . . , there is no longer a single best technology for telecommunications transmission. . . . The variety of competing transmission technologies implies that it is no longer possible to define a natural monopoly technology for local technology.'' Recent evaluations of the natural monopoly condition seem to corroborate this last assertion (see Sung and Gort 2000).

i.e., political opportunism is less likely with a greater consensus, for instance, a legal mandate in a law passed by a national congress rather than a presidential decree.

REGUL, the main variable, is an index of the regulatory framework in telecommunications for every country. This index has three dimensions. The first reflects whether there is separation of telecom operations and regulatory activities (ITU 1993), although not necessarily whether there is a specialized and separate regulatory body. The second dimension reflects the following features of independent regulatory agencies: (i) whether the regulatory body has autonomy (e.g., whether there is budgetary independence or limits on government's ability to freely replace regulators; see Gutierrez 2002), (ii) accountability, measured by existence of mechanisms to resolve disputes between regulators and operators, (iii) clarity of the regulator's roles in terms of ability to set tariffs and fine or penalize operators, and (iv) transparency and participation in the regulatory process. The last dimension is whether the creation of the regulatory body (or the separation of the operating and regulatory activities) is backed by law or some minor norm (presidential decree, etc).

Index dimensions are weighted and summed by assigning equal value to every component; i.e., the first and third dimensions, with just one component, have a weight of about 16.6% each, as does each of the four components of the second dimension. The index reflects continuous growth to the extent that countries adopt new regulatory legislation; unfortunately, the index will always show increases unless the new legislation rules out some of the criteria already in place.

Still subject to some shortcomings, the current index improves on those in Gutierrez and Berg (2000), Wallsten (2001) and Bortolotti (2002) by considering the evolution of regulation rather than its complete presence or absence. Countries display a great range of change and instability in their polity, and a variable purporting to capture regulatory performance should reflect this. Also, an index that presents a stepwise development of regulatory governance allows testing of more complex hypothesis. This is the first study to use an index of this type with econometric analysis to address network deployment and efficiency in Latin America and the Caribbean.

As in most other econometric studies cited, the model controls for economic and demographic variables. According to economic theory, income may be the most important factor driving demand.[5] Here the proxy for income is gross domestic product per capita (GDPPC), the sum of exports plus imports as a percentage of GDP (TRADE), and the ratio of the value added by the services sector, net of transportation and telecommunications, to the GDP (VSER). Since cost factors affect supply of telecom services, I proxy costs by using either DENSITY, the ratio of population to area, or URBAN, the total percentage of urbanized population, with the expectation that the more densely populated or more urban a country, the lower should be the cost to deploy a

5 As Saunders et al. (1994, 203) assert, ''On a national basis, the input-output analysis suggested that the most frequent users of business telephones in developing countries as well as industrial countries are persons employed in trade, services, government administration, and to some extent transport. In other words, the tertiary sector of an economy generally purchases the largest quantity of telecommunications services.''

network and so the more network will be deployed.[6] The main statistics, the correlation matrix, and a table showing the means for main variables for every country are presented in the Appendix.[7]

3.1. Telecom Reform Variables: Exogenous or Endogenous?

In studying the effects of telecom reform on performance, two main approaches have been followed regarding whether the telecom reform variables of regulation, privatization and competition should be exogenous or endogenous. Ros used a Hausman test of no correlation between the explanatory variables (the dummy variables for competition and privatization) and the error terms across time. The results validated the assumption that both variables were endogenous. Wallsten (2001) simply assumed that regulation, privatization and liberalization were exogenous and ran panel data techniques (fixed effects). No statistical tests were run and no reasons were advanced for the assumption even from a theoretical point of view. However, as he says (2001, 18), ''Future work should concentrate on improving data on regulation, gathering firm-level data, and *endogenizing reform efforts such as competition, privatization, and regulation*'' (emphasis added).

In her study of the relationship between the economic influence and characteristics of political institutions in telecommunications sector, Smart (1994, 301), states that

> For most firms, the regulatory environment constitutes an important determinant of the cost of operating in a specific country or region. Not surprisingly, strategic decisions made by firms may be linked not only to such traditional economic variables as the costs of labor and capital, but also to varying regulatory conditions.

Her remark shows how the performance of the telecom industry affects and is affected by political and regulatory decisions. One striking insight that can be taken from the country studies of telecommunications reform in the region is that, for most countries, privatization, liberalization and regulatory enhancement were closely linked and each influenced the other as well as telecom performance. For instance, the implementation of regulatory bodies led new privatized telco operators to lobby for policies favoring them and to utilize all legal procedures to delay the introduction of new competition, thus affecting performance. Liberalization and privatization also raised new problems for regulators in such areas as interconnection and universal service, which affect telcos' incentives and behavior and thus their performance.

Endogeneity of telecom dimensions seems obvious from the empirical studies and is also appealing from a theoretical point of view. I therefore followed the practical

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6 Price variables like monthly fees, costs of long distance calls and installation charges are not included in any of the models. Despite their being important, I chose to leave them out of the models because the quality and availability of data on prices were scarce or lacking for most of the countries. To illustrate, the ITU database for prices (i.e., cost of three minutes local and connection charges) gives only about 20–28% of the total country-year observations. In some cases, the same information was provided for two different variables. Since my study covers the 1980–1997 period, the lack of so many observations would make panel regressions and their results unreliable.

7 For more about demand and cost factors in telecommunications, see Falch (1997).

procedure of first running tests to see whether the three variables were endogenous from a statistical point of view. A Hausman test for the whole sample of 22 countries to discover whether the error terms are correlated with the three dimensions of regulation, privatization and liberalization showed that the null hypothesis of exogeneity cannot be rejected. However, for the subsample of 12 countries of lower income, the null hypothesis of no correlation is rejected, as the variables must be considered endogenous. With mixed statistical evidence, I prefer to consider the dimensions as endogenous in view of insights from the literature on telecom reform in Latin America. For all specifications, regressions are run by treating them first as exogenous and then as endogenous, with inferences made from the latter. This is done more emphatically in the dynamic model part.

4. Econometric Analysis

In the theoretical literature on telecommunications, there is no indisputable guideline for the functional form that will explain network expansion. As the survey by Kridel et al. (1996) shows, research trying to link incentive regulation with some performance or investment measure in telecommunications has yielded mixed results. Some authors prefer linear models while others use non-linear ones. The studies quoted in the empirical section use different kinds of approximations, but use linear models, with the variables either in levels, in logarithmic or semi-logarithmic functional form. In this study of how and to what extent level of network deployment and efficiency is affected by the regulatory environment and how privatization and liberalization may have contributed to telecommunications development, I follow Ros (1999) and Ros and Banerjee (2000) and use a semi-logarithmic functional form, exploiting in full the regulatory framework constructed in Gutierrez (2002).

Previous studies have been limited to static analysis. This study goes a step further by analyzing both static and dynamic models of network deployment. Panel data techniques are used to conduct the econometric analysis for both models. Additionally, since the data span eighteen years (1980–1997), it is convenient for analysis to include time dummies that may capture changes in economic and industry environment. The period under study includes important events, both economic and political, that affected Latin American economies, and telecommunications underwent dramatic technological changes at the same time. Thus, it seems important to control not only for country-specific effects but also for time effect.

4.1. Static Panel Data

Our static model is then

$$\ln y_{it} = x_{it}\beta' + d_{it}\delta' + \alpha_i + \varepsilon_{it} \quad i = 1, \ldots, N, \text{ and } t = 1, \ldots t, \tag{1}$$

where $x_{it} = (x_{1it}, x_{2it}, \ldots, x_{\mathrm{K}it})'$ represents the regulatory framework index as well as the number of control (explanatory) variables that have been shown meaningful in explaining telecommunications performance in most past studies, $\beta = (\beta_1, \beta_2, \ldots, \beta_{\mathrm{K}})'$ are their

respective parameters; the dummies variables are $d_{it} = (d_{1it}, d_{2it})'$ and their parameters, $\delta = (\delta_1, \delta_2)'$. I assume that ε_{it} may follow a one-way or two-way error component model. Thus,

$$\varepsilon_{it} = \mu_i + \nu_{it}, \tag{1a}$$

or

$$\varepsilon_{it} = \mu_i + \lambda_t + \nu_{it}, \tag{1b}$$

where α_i and λ_t represent country and time effects, respectively, which I assume to be fixed. The remaining (individual and time-specific effect) ν_{it} is assumed to be i.i.d. with mean 0 and variance σ_ν^2.

Our dependent variable $\ln y_{it}$ is either teledensity (main lines per 100 inhabitants) or efficiency (employees per main lines). Among the x_{it}-vector variables, I include GDPPC, TRADE, VSER, and VMAN (the percentage of trade, and value added by the service and manufacturing sector to GDP), all lagged one period, as well as URBAN and DENSITY. Lastly, the d_{it} vector represents the dummies for competition (a value of 1 if competition exists, zero otherwise) and privatization (a value of 1 whenever more than 50% of the former state-owned operators is sold to private investors, zero otherwise).

Endogeneity is a pervasive problem in econometric analyzes of policy impacts. Most studies have assumed that their variables of interest were exogenous. For instance, Wallsten (2001, 12) states, ''competition, privatization and regulation may be endogenous to reforms. That is, reforms affect telecom performance, but performance may also affect reforms.'' Ros (1999), quoting Kridel et al. (1996), also raises the point that competition and privatization (and perhaps regulation) may be endogenously determined. This is an important issue. Similarly to Ros, I assume that competition and privatization are more likely than regulation to be endogenous, at least in this first stage of telecommunications reform. The privatization and competition processes in Latin American and the Caribbean, although fast in many countries, were accomplished through the negotiation of key issues, the most important of which was the exclusivity period, the fulfillment of some goals in performance and quality and so on.

Levy and Spiller (1996) have made clear the distinction between regulatory governance and regulatory incentives. The governance framework includes mechanisms to restrain government behavior and solve disputes, while the regulatory incentives focus on pricing, subsidies and operating policies. As Levy and Spiller stress, researchers have paid too much attention to regulatory incentives and have disregarded regulatory governance. The measure of the regulatory framework in telecommunications presented here focuses completely on regulatory governance in telecommunications, leaving (perhaps) less room for any problem of endogeneity. I assume regulation to be exogenous in the static model and consider the endogeneity aspect in the dynamic model. After all, telecommunications performance is affected by regulation, while regulation, in turn, can be affected by performance.

Following Donald and Sappington (1995), when assuming that privatization and competition are endogenous and within the frame of a static analyzes, I first run a logit model to analyze the discrete choice of allowing competition and privatization, or not. d_{it}

and d_{jt} stand for competition and privatization, respectively. Each will take the value of 1 if the event takes place (competition or privatizations exists) in basic telecommunications services, zero otherwise. In other words, I have, two additional equations.

$$d_{it} = \beta' x_{it} + u_{it}, \quad i = 1, 2. \tag{2}$$[8]

$$\text{Prob}(d_{it} = 1) = \text{Prob}(\mu_i > -\beta' x_{it}) = 1 - F(-\beta' x_{it}) i = 1, 2,$$

and using a logit model, I get $\hat{p}$ as

$$1 - F(-\beta' x_{it}) = \frac{e^{\hat{\beta} x_{it}}}{1 + e^{\hat{\beta} x_{it}}} = \hat{p}.$$

Then, using the fitted value coming from the logit model of equation (2), interacting those values with the original values (as in Ros, 1999), I run a two-stage least square dummy variable model to assure consistent and efficient estimators of equation (3),

$$\ln y_{it} = x_{it}\beta' + d_{it}(\hat{p})\delta' + \alpha_i + \varepsilon_{it} \quad i = 1, \ldots, N, \text{ and } t = 1, \ldots T. \tag{3}$$

5. Static Panel Data Findings

The results of the fixed-effect models, equation (3), explaining the impact of telecommunications reforms on network expansion are shown in tables 1 and 2, while table 3 shows the effects of the same variables on the level of efficiency. To facilitate interpretation, the results are organized as follows in tables 1 and 2. The estimates obtained by assuming all regressors are exogenous are shown in the first two columns to allow, whenever possible, a comparison with Wallsten's estimates. Outcomes after correcting for endogeneity of competition and privatization (see equation (3)) are presented in the next two columns.

In table 1, the regulation variable is interacted with competition and privatization. I have then two interacted variables. In table 2, I extend the analysis of the regulation variable, running regressions where that variable enters in level as well as in square term in an attempt to determine whether a nonlinear relationship exists between regulation and telecom performance. Additionally, since the regulatory framework index (RFI), is the sum of three main dimensions, I enter each of them separately as regressors (columns 5–8,

8 I follow Heckman (1978, 947) who suggests that ''if the sole purpose of the analysis is to estimate equation (1), it is not necessary to estimate probit functions at all. It is possible to generate an instrumental variable for d_{it} by estimating a simple linear probability model with d_{it} as a dependent variable that contains at least all of the variable in x_{it} and some other exogenous variable as regressors. If theses estimators are utilized, the standard two stage least squares procedure applies and predicted values of d_{it} may be utilized as regressors since in this case the regression residuals from the prediction of d_{it} are constructed to be orthogonal to the x_{it} regressors.''

Table 1. Parameter Estimate for Log of Main Lines per 100 Inhabitants—22 Countries

	Fixed Effects All Main Variables as Exogenous		2SLS Fixed-Effect with Endogenous Competition and privatization		Fixed Effects All Main Variables as Exogenous	
Regressors	1	2	3	4	5	6
Regul (− 1)	0.268*	0.124*	0.220*	0.105*	0.161*	0.045
t	(9.6)	(3.82)	(7.15)	(3.26)	(4.09)	(0.98)
Comp	0.084*	− 0.011	0.105*	− 0.009	0.064*	− 0.02
t	(7.91)	(− 0.95)	(6.4)	(− 0.52)	(4.34)	(− 1.45)
Owner	0.098*	0.05**	0.167*	0.12*	0.021	− 0.023
t	(5.29)	(2.91)	(6.66)	(5.63)	(0.98)	(− 0.94)
Regul*Comp (− 1)					0.08**	0.041
t					(2.07)	(1.21)
Regul*Owner (− 1)					0.167*	0.164*
t					(4.05)	(3.99)
GDPPC (− 1)	8.7E-05*	7.4E-05*	7.4E-05*	6.4E-05*	6.4E-05*	5.E-05*
t	(4.6)	(5.32)	(4.07)	(4.76)	(3.47)	(3.9)
Trade (− 1)	− 5.7E-04	7.9E-05	− 7.9E-04***	− 2.7E-04	− 7.1E-04***	− 2.2E-04
t	(− 1.3)	(0.31)	(− 1.98)	(− 1.14)	(− 1.7)	(− 0.96)
Density (− 1)	0.012*	0.006*	0.011*	0.007*	0.012*	0.006*
t	(11.72)	(7.67)	(11.36)	(8.65)	(12.26)	(8.09)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	No	Yes	No	Yes
R-sqr	0.948	0.969	0.945	0.967	0.9517	0.9722
Hausman[a]	74.58*	108.73*			105.73	87.89
N-obs.	374	374	374	374	374	374
Instruments used in logit regressions (aside from main regressors above)	—	—	Civil and political liberties indexes, and FDI/GDP	Civil and political liberties indexes, and FDI/GDP	—	—

Notes. The t-ratios in parentheses are robust to heteroskedasticity; *statistically significant at 1%, **statistically significant at 5%, and ***statistically significant at 10%.
[a] Hausman test of Ho: Random-effects vs. fixed-effects.

in table 2). To see whether lower economic development in a country creates different relationships between telecom performance and the reform variables, I performed the same econometric runs for a subsample of countries with a GDPPC lower than $2400 (in 1995 U.S. dollars). To save space the results are shown in the Appendix, in tables A1 and A2 for network deployment and A3 for efficiency.

Finally, a Hausman test of a null hypothesis of random-effect rejects the null at a 1% significance level for almost all the regressions (see Baltagi 2001, 65–7). In this regression and the following ones, a Hausman test will determine whether to opt for the fixed-effects or the random-effects estimation procedure.

5.1. Main Lines per 100 Inhabitants, Full Sample of 22 Countries

Two general observations can be made. First, there is no fundamental difference between the results obtained by assuming all variables are exogenous and those corrected

Table 2. Parameter Estimate for Log of Main Lines per 100 Inhabitants—22 Countries

	Fixed Effects. All Main Variables as Exogenous		2SLS Fixed-Effect with Endogenous Competition and Privatization		Fixed Effects. All Main Variables as Exogenous		2SLS Fixed-Effect with Endogenous Competition and Privatization	
Regressors	1	2	3	4	5	6	7	8
Regul (− 1)	− 0.009	− 0.224***	− 0.053	− 0.203***				
t	(− 0.06)	(− 1.86)	(− 0.35)	(− 1.74)				
$[\text{Regul}(-1)]^{2_{2,\ldots,2}}$	0.262***	0.326*	0.307**	0.295***				
t	(1.84)	(3.16)	(2.96)	(1.91)				
Separation (− 1)					0.068**	0.064**	0.0073**	0.072*
t					(2.37)	(2.95)	(2.58)	(3.45)
ITU/Ten (− 1)					0.137*	0.064***	0.11**	0.048
t					(3.51)	(1.75)	(2.79)	(1.33)
Legal (− 1)					0.056**	0.001	0.041	− 0.01
t					(2.14)	(0.03)	(1.54)	(− 0.42)
Comp	0.088*	− 0.008	0.114*	− 0.002	0.083*	− 0.014	0.094*	− 0.01
t	(7.95)	(− 0.67)	(7.24)	(− 0.13)	(7.69)	(− 1.23)	(7.69)	(− 0.63)
Owner	0.094**	0.044*	0.133*	0.089*	0.1*	0.056*	0.18*	0.135*
t	(2.63)	(5.23)	(5.72)	(4.28)	(5.5)	(3.32)	(6.79)	(5.33)
GDPPC (− 1)	8.91E-05*	7.64E-05*	7.8E-05*	7E-05*	9.1E-05*	7.26E-05*	7.8E-05*	6.1E-05*
t	(4.74)	(5.69)	(4.42)	(5.42)	(4.77)	(5.14)	(4.26)	(4.17)
Trade (− 1)	− 5.8E-04	− 7.7E-04	− 7.4E-04***	− 2.1E-04	− 6.6E-04	− 1.51E-04	− 8.9E-04**	− 3.8E-04
t	(− 1.32)	(− 0.3)	(− 1.83)	(− 0.88)	(− 1.49)	(− 0.59)	(− 2.2)	(− 1.61)
Density (− 1)	0.012*	0.006*	0.011*	0.006*	0.012*	0.006*	0.011*	0.007*
t	(12.56)	(8.29)	(11.94)	(9.07)	(11.2)	(7.27)	(11.23)	(8.19)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	No	Yes	No	Yes	No	Yes
R-sqr	0.9487	0.9705	0.9469	0.9695	0.9485	0.97	0.9451	0.9671
Hausman[a]	376.43*	151.64			119.23*	439.56		
N-obs.	374	374	374	374	374	374	374	374
Instruments used in logit	—	—	See Table 3	See Table 3			See Table 3	See Table 3

Notes. The *t*-ratios in parentheses are robust to heteroskedasticity; *statistically significant at 1%, **statistically significant at 5%, ***statistically significant at 10%.
[a] Hausman test of Ho: Random-effects vs fixed-effects.

for endogeneity of competition and privatization (following Heckman's criteria). The estimates and the statistical significance are very similar. Second, the inclusion of year dummies alters the estimates. With the exception of Trade, all the estimates are about half the value when these dummies are excluded.

Examining table 1, I can conclude that a better regulatory environment for telecommunications is definitely associated with better performance in the sector, measured by main lines per 100 inhabitants, whether year dummies are included or not.[9] A one-point enhancement in regulation conveys an increase in main lines per 100 inhabitants of 4.5–26.8% in the static model. This illustrates the policy implications of a stronger regulatory framework. My values are a little bit greater than the values found by Wallsten, but then the sample and model specification are different.

Privatization is also positively associated with network expansion. This corroborates Ros, although my values are considerably lower than his. Ros found that network expansion was almost 31% greater in countries that privatized their former state-owned telco. The impact ranges between 10 and 18% in this study, in contrast to Wallsten, who reported a negative association between privatization and the level of network deployment, though not statistically significant.

Competition, is also positively associated with an increase in network expansion but only when year dummies are not included. The former result is distinct from Ros, who reported no significant effect, but conforms with Wallsten, who used a different measure of competition but reported its positive effect on telecom lines deployment. The economic effect of competition is less than that of privatization, but competition is a relatively new phenomenon in Latin America's basic telecommunications services. In general, results from the static model verify that reform that involves privatizing former state-owned operators, allowing competition, and implementing better regulatory governance leads to better telecom performance.

Other observations can be made regarding table 1. When regulation is interacted with competition and privatization and added to the model, the estimate value of the regulatory variable falls about 40%. Moreover, when I include year dummies to capture some time-specific events, the variable is no longer statistically significant, although its sign remains positive. Also, estimates for privatization are no longer statistically significant. When I exclude year dummies, both interacted terms become positively associated with main lines per 100 inhabitants. In general, these results differ from Wallsten's. His regulatory variable, alone and interacted with competition, were not statistically significant, and privatization was negatively associated with the dependent variable.

There are two possible explanations for these differences. First, I consider only Latin American countries while Wallsten's sample includes fifteen African countries. This may introduce a larger heterogeneity that is not controlled for. Second, as mentioned earlier, his competition and privatization variable differs from mine. While he proxies competition with the number of wireless operators, I use it as a dummy variable with a value of 1 whenever entry was allowed in telecom basic services or as wireless service began. Wallsten defines privatization as beginning the moment a government started divesting its

9 We recall that all *t*-ratios are robust to heteroskedasticity, which makes the inference more reliable.

state-owned operator, no matter the percentage of the divestment. I define privatization as divestments greater than 50%.

Both income and cost proxies are also significant and with the expected sign. GDPPC is associated positively with a greater network deployment. The impact of income is apparently very low when analyzing the size of the coefficients. Ros found that increases of $1,000 in GDPPC resulted in a 20% increase in main lines per 100 inhabitants (in the next period). My results show that an increase of $1,000 will produce only a 0.005–0.008% increase in network deployment. Density, our cost proxy, is positive and its effect on network is somewhat greater than GDPPC. Trade, the sum of exports plus import as a proportion of GDP, did not have the expected sign and usually is not even statistically significant.[10]

Table 2, where the regulations variable is included in different ways, also shows important results. I introduce the three different components of Gutierrez's (2002) RFI. Basically, these are concerned with whether there is separation of regulatory and operational activities in basic telecommunications, whether the four elements that practitioners stress as fundamental for a regulatory body are present, and which legal mandate supports the regulatory environment in telecommunications in each country. All in all, estimates are good.

Columns 1–4 in table 2 reflect the effort to determine whether the relationship between the regulatory environment and telecom performance may be nonlinear, either because the RFI has three dimensions (each one measuring different aspects of regulation) or because the association between those variables is by itself nonlinear. One can argue that once the regulatory environment reaches some level, government and congress might not want to further regulatory reforms or that for low levels of regulatory governance there is a need for strengthening institutions. The results suggest that, at low levels of regulation, further enhancement of the regulatory framework increases telecom performance and then slowly diminishes in its impact on performance.[11]

A criticism of the RFI may be that its components are measured differently and that it would be better to quantify the individual effect of each dimension, but the general validity of the RFI is clear (columns 5–8 of table 2). Focusing just on the one-way effects, I notice that all components are economically significant (although the coefficient for Legal was not statistically significant). The component with the greater effect, measured by coefficient size, is the one summarizing characteristics suggested by practitioners, followed by Legal and then by Separation. However, when year dummies are included, Separation and those characteristics taken from ITU/Tenenbaum keep their expected statistical significance, but Legal is now negative. In conclusion, either alone, with its square term, or with its three components, the RFI keeps its power in explaining better telecom performance, in a static model.[12]

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10 In general, the estimates for other economic variables were poorer than for Trade and so were dropped.

11 When regulation enters directly in a quadratic form, the estimated coefficient on the linear term is negative (− 0.009 to − 0.224) and only significant in two-way effect models, while that on the squared term is positive, greater in size (0.262–0.326) and highly significant. The *p*-values for joint significance of the two terms are always highly significant.

12 In all cases, the sum of three coefficients is between 0.11–0.224 comparable to the single coefficients on table 2. Also, the *p*-values for joint statistical significance of the three components of the RFI are 0.0000.

5.2. Main Lines per 100 Inhabitants for a Subsample of 12 Countries

In this subsection I briefly review the results found for those countries with lower income. It is meant to show how the results are sensitive to a factor important to the level of development. The results for low-income countries in the region shown in tables A4 and A5 (in the Appendix) are similar to the general observations made for the full sample. However, some particularities can be noticed. First, the parameters of the regulation variable are lower than for the full sample. This may mean either that it is more difficult to implement better regulatory governance in low-income countries or that regulatory enhancement is still a very recent event and that its effects cannot be captured yet. Second, the other telecom reform variables, competition and privatization, have greater impact for lower-income countries than for higher-income ones. The main reason may be that telecom performance was so poor prior to the entry of competition and the privatization that there was greater room for improvement.

For income and cost variables, the results are mixed. For both samples, income (GDPPC) was always economically significant, but has slightly larger parameters for countries with GDPPC below $2,400. The explanation may lie with economic conditions (debt crisis, high fiscal deficit, and the like) that have affected lower-income countries in greater measure. However, the cost proxy variable has the expected sign and is significant in all cases.

Although the estimated coefficients in table A5 are weaker than for the full sample, the behavior is similar. The coefficient of the square term of regulation is always positive (ranging from 0.173 to 0.32) for two-way effect models but insignificant statistically when year dummies are excluded. The linear term is negative (ranging from -0.283 to -0.013) and significant for the two-way effect model too.[13]

In this static model, for countries with low levels of economic development, it seems that better regulatory governance is less successful in impacting network deployment. The poor estimates of the regulation variable reported by Wallsten (2001) are similar to mine for his sample of fifteen African countries that, on average, have lower economic development. More studies in this line of research are needed to verify the hypothesis that the impact of regulatory governance on performance may be lower in countries with lower economic development.

5.3. Efficiency

Table 3 shows how the telecom reform and control variables affect telecommunications efficiency. Although, arguments can be made about the endogeneity of competition and privatization, I simplify analysis by assuming all variables are exogenous.

In general, the estimate coefficients obtained for Efficiency replicate the outcomes shown for Teledensity. My main variable, the RFI, correlates positively with the level of efficiency, when entered alone as a linear term, when entered with its square term, or when entered as its three components.[14] Privatization reform turns out to affect the number of

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13 The joint significance attained is high (p-value is 0.000). Regarding columns 5–8, the results are, in general, mixed. Half of times, the signs are the expected ones but not statistically significant.

14 All parameters are statistically significant, except for Legal in column 8. Besides, the p-values for joint significance (for columns 4–8) are 0.000.

Table 3. Parameter Estimate for Log of Efficiency—22 Countries

	Fixed Effects All Main Variables as Exogenous							
Regressors	1	2	3	4	5	6	7	8
Regul (−1)	0.511*	0.28*	0.340*	0.156**	−0.035	−0.034		
t	(9.93)	(5.41)	(5.83)	(2.58)	(−1.59)	(−1.59)		
[Regul (−1)]^2					0.5148	0.586		
t					(2.3)**	(2.92)**		
Separation (−1)							0.091**	0.0955**
t							(2.47)	(2.94)
ITU/Ten (−1)							0.268*	0.149**
t							(4.49)	(2.59)
Legal (−1)							0.12748*	0.0359
t							(4.2)	(1.24)
Regul*Comp (−1)			0.127**	0.284*				
t			(2.21)	(5.00)				
Regul*Owner (−1)			0.267*	0.051				
t			(4.47)	(1.22)				
Comp	0.127*	0.005	0.095*	−0.004	0.133*	0.011	0.1263*	0.002
t	(8.5)	(0.32)	(4.42)	(−0.27)	(8.93)	(0.74)	(8.47)	(0.13)
Owner	0.095*	0.048**	−0.029	−0.077**	0.085*	0.036***	0.094*	0.054**
t	(3.88)	(2.18)	(−0.87)	(−2.56)	(3.51)	(1.7)	(3.75)	(2.41)
GDPPC (−1)	9.46E-05*	5.26E-05**	5.73E-05**	1.97E-05	9.83E-05*	5.74E-05**	1.02E-04*	5.4E-05**
t	(3.78)	(2.76)	(2.27)	(0.95)	(3.99)	(3.11)	(4.16)	(2.84)
Trade (−1)	−6.59E-04	−1.56E-04	−8.8E-04**	−4.04E-04***	−6.74E-04	−1.5E-04	−8E-04*	−2.75E-04
t	(−1.48)	(−0.6)	(−2.1)	(−1.72)	(−1.51)	(−0.58)	(4.16)	(−1.10)
Density (−1)	0.008*	7.78E-04	0.008*	0.001	0.008*	0.001	0.008*	0.001
t	(8.83)	(0.78)	(9.49)	(1.38)	(9.54)	(089)	(8.55)	(0.82)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	No	Yes	No	Yes	No	Yes
R-sqr	0.9083	0.9413	0.9169	0.9492	0.9107	0.9449	0.9449	0.9422
Hausman[a]	86.46*	1.411	295.57*	3.73	150.34*	1.82	84.41*	3.07
N-obs.	374	374	374	374	374	374	374	374

Notes. The *t*-ratios in parentheses are robust to heteroskedasticity; *statistically significant at 1%, **statistically significant at 5%, and ***statistically significant at 10%.
[a] Hausman test of Ho: Random-effects vs fixed-effects.

main lines per employee positively, and competition seems to enhance efficiency more than privatization. Income and cost variables have the expected sign and statistical significance. Again, Trade has a negative sign and is not even statistically significant most times.

Table A6 presents the estimates obtained for the subsample of countries with GDPPC lower than $2,400 (U.S. dollars). Results are similar to those for the full sample. A better regulatory environment will, on average, enhance efficiency. Privatization is mostly associated positively with greater level of efficiency while competition repeats the pattern of the full sample. However, the cost variable has a better effect on efficiency than income as evaluated by its estimated coefficient.

6. Dynamic Panel Data

The preceding analysis was done within a static framework. Richer insights can be obtained when analyzing telecom reforms in a more dynamic environment. Nerlove (2000, 19) argues that all models of economic behavior are basically dynamic, stating that

> current behavior is almost always dependent on the state of system describing it, and this state in turn often depends on how it got to where it is. In the simplest cases state dependence may be expressed as a distributed lag or by the inclusion of lagged values of the endogenous behavioral variables but sometimes the dynamics is implicit as when current investment expenditure are assumed to depend on the capital stock. The arbitrary nature of calendar time in relation to the relevant date or period over which behavior is measured is also a source of dependence over time among observations.

In this section, I look at the behavior of my telecom reform variables on performance within a (simple) dynamic context and, following Nerlove, hypothesize that telecom performance and efficiency are affected by past achievements.[15]

The econometric of dynamic panel data has and is still experiencing great development. Although the attempt is modest here, I hope the benefits of this kind of analysis will be apparent. Our dynamic model is:

$$\ln y_{it} = \ln y_{it-1}\gamma' + x_{it}\beta' + d_{it}\delta' + \varepsilon_{it} \quad i = 1, \ldots N, \quad \text{and} \quad t = 1, \ldots T, \tag{4}$$

where, as before, ε_{it} may follow a one-way or two-way error component model. Equations (1a) and (1b) also apply.

The simple estimation of equation (4), using either the within transformation or least square dummy variables, LSDV, will give inconsistent estimators because both ε_{it} and μ_i

15 A look at the more recent literature of Latin American telecommunications development will validate a dynamic analysis. Gutierrez (1999) describes in more detail the commitments that new private owners of former state operators agreed to. Among other things, they had to implement some timetable schedule of main phone lines deployment, improvement in quality, and reductions in waiting lists.

Table 4. Parameter Estimate for Log of Teledensity

	All Main Variables as Exogenous					
Regressors	Within 1	A-H 2	GMM 3	Within 4	A-H 5	GMM 6
LogTeleden (− 1)	0.877*	0.978*	0.7748*	0.871*	0.984*	0.7287*
t	(27.2)	(8.69)	(8.59)	(29.4)	(8.3)	(8.59)
Regul (− 1)	0.08*	0.07**	0.0698**	0.0715**	0.0742***	0.065***
t	(4.56)	(2.64)	(2.70)	(3.2)	(1.85)	(1.78)
Regul*Comp (− 1)				− 0.0152	− 9.03E-03	− 0.0183
t				(− 0.62)	(− 1.03)	(− 0.65)
Regul*Owner (− 1)				0.0472**	0.0621***	0.0771**
t				(2.07)	(1.91)	(2.28)
Comp	0.0109**	− 3.46E-03	0.0091	0.016***		0.124
t	(2.16)	(− 0.36)	(0.84)	(1.7)		(1.11)
Owner	0.018**	5.41E-03	0.0282	− 5.1E-04	6.6E-03	5.8E-03
t	(2.2)	(0.20)	(1.19)	(− 0.05)	(0.25)	(0.3)
GDPPC (− 1)	3.1E-05*	3.3E-05**	2.35E-05	2.8E-05*	3E-05**	1.88E-05
t	(4.46)	(2.73)	(1.59)	(3.9)	(2.43)	(1.21)
Trade (− 1)	1.2E-04	4.8E-04**	5.7E-04**	7.67E-05	4.4E-04**	4.1E-05***
t	(1.01)	(2.35)	(2.41)	(0.66)	(2.28)	(1.92)
Density (− 1)	1.1E-03**	6.5E-05	1.1E-03	0.0012**	3.1E-04	1.55E-03**
t	(2.73)	(0.02)	(1.51)	(3.08)	(0.11)	(2.2)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-sqr	0.9928	0.2256	—	− 0.993	0.2372	—
Serial correlation	—	—	0.3136	—	—	0.7017
N-obs	352	352	352	352	352	352

Notes. The *t*-ratios in parentheses are robust to heteroskedasticity; *statistically significant at 1%, **statistically significant at 5%, and ***statistically significant at 10%. The serial correlation is the *p*-value of a test for second-order serial correlation in the residuals of the difference equations.

(in equations (1a) and (1b)) are correlated. The problem becomes more acute for micro panels where $N \to \infty$ and T is fixed. For macro panels, $T \to \infty$ and N is fixed, so the estimation will give consistent estimates, although a bias for either $\hat{\gamma}$ or $\hat{\beta}$ will appear. Different solutions have been proposed for problems of this sort, including (1) instrumental variable estimation that utilizes Anderson-Hsiao IV estimators (see Hsiao 1986), (2) correction of the LSDV bias with Kiviet's bias correction (see Kiviet 1995) and generalized method of moments estimation (see Matyas 2000). Among the GMM, the estimators attributed to Arellano and Bond (1991) are the most widely applied in empirical econometric. All these except Kiviet's are used in this analysis of the dynamic of telecom performance for a sample of Latin American countries.

For the strict and partial exogeneity, analysis will be done on just one of the two performance variables, main lines per 100 inhabitants or teledensity. Different assumptions will be made regarding the endogeneity of privatization, competition and regulation. Finally, the analysis will be concerned only with the full sample of 22 countries and either the one-way or two-way error component model outcomes will be presented.

6.1. Exogenous Model

Table 4 presents the results for a dynamic model where all the telecom reform variables are exogenous. Three different estimates are given. The first (columns 1 and 4) shows the

within estimator (or LSDV) that, as mentioned, has a bias in all coefficients, although it matters more for the lagged value than for the other parameters. Estimators proposed by Anderson and Hsiao (1981) are displayed in columns 2 and 5, while columns 3 and 6 register the GMM estimator from Arellano and Bond (1991).

The standard LSDV model with a lagged dependent variable generates biased estimates when the time dimension of the panel (T) is small. The main problem appears whenever T is fixed and N tends to infinity, which is typical in micro panels that give inconsistent estimates. To address the problem, Anderson and Hsiao (1981) proposed taking the first differences of (4) and, since $\Delta y_{it} = y_{it} - y_{i,t-1}$ is correlated with the residual Δu_{it}, use as instruments either $y_{i,t-2}$ or $\Delta y_{i,t-2}$.[16] I use the first of these, and the transformation yields consistent estimators of the parameters in equation (4). Lastly, Arellano and Bond (1991) proposed new estimators called GMM. The Anderson-Hsiao estimator uses $y_{i,t-2}$ as an instrument that is uncorrelated with $\Delta u_{i,t}$ and so demonstrates the so-called orthogonality condition, i.e., $\mathrm{E}(\Delta u_{it} \mathrm{y}_{i,t-2}) = 0$ for all $t = 2 \ldots T$. Considering other ways of combining the information in the different orthogonality conditions and/or considering more orthogonality conditions generates the so-called generalized method of moments (GMM) estimators proposed by Arellano and Bond. Although the Anderson-Hsiao estimator is consistent, it is not efficient because, among other reasons, it does not exploit all the orthogonality conditions; thus the claim for the greater efficiency of the GMM.

Focusing on our telecom reform variables, I notice that, under the assumption of full exogeneity, a better regulatory framework is always positively associated with better telecom performance in a dynamic context, confirming the results obtained in the static model. The estimated coefficients for the regulatory variable are 40–50% higher than the ones in the static model. Conversely, neither privatization nor competition is statistically important in explaining the performance of telecommunications. However, when regulation is interacted with privatization, it is positively associated with network deployment, as was the case in the static version. The estimated coefficient of the lagged dependent variable is always positive and has the higher statistical significance, appearing to be the most important factor explaining network deployment.

Since the double log relation is used, the coefficient shows the elasticity between the current level of network deployment and the past level achieved. This elasticity ranges between 77 and 98%. In the literature on Latin American telecommunications, analysts have stressed new telco operators' commitments to deploy lines. The positive and significant relationship between the interacted terms (regulation times privatization) may indicate how that commitment was implemented, although the coefficients are very similar across the different estimators.

The income and cost variables show different results. While GPPPC has the expected sign and is mostly significant, Trade becomes significant half of the time, having been negatively associated with teledensity in the static model. Density, the cost proxy, is only statistically significant in Arellano and Bond's estimator. In general, the dynamic version

16 Anderson and Hsiao's solution lies in removing country-specific effects by differencing the data. Then equation (4) becomes: $\Delta y_{i,t} = \Delta y_{it-1}\gamma' + \Delta x_{i,t}\beta' + \Delta d_{i,t}\delta' + \Delta \varepsilon_{i,t}$.

of the model presents a better specification of the model, with the unrealistic assumption that all telecom reform is strictly exogenous.[17]

6.2. Partial and Full Endogenous Models

I posit that the three telecom reform variables—regulation, privatization and competition—are predetermined or endogenous, which could introduce more econometric complications. However, under the assumption that competition and privatization, $d_{it}, i = 1, 2$, and regulation, (x_{it}), are predetermined, $d_{i,t-1}$ and $x_{i,t-1}$ are valid instruments, and $x_{i,t-2}$ and $d_{i,t-2}$ are valid if d_{it} and (x_{it}) are endogenous, as I assume. Noting that $x_{i,t-2}$ and $d_{i,t-2}$ are also valid instruments if $x_{i,t-1}$ and $d_{i,t-1}$ are valid, it is evident that when the panel of countries is a set of cross-country regressions, the number of valid instruments in each cross-section is increasing in the time dimension (to exploit all orthogonal conditions). This property is used in Arellano and Bond's GMM estimator. Additionally, the estimator is linear and its estimation is eased by the availability of econometric software. I now present coefficient estimates for full or partial endogeneity of telecom reform variables.

Table 5 gives GMM estimators when assuming privatization and competition are endogenous. Again, the regulation variables have the expected positive association with main lines per 100 inhabitants. However, as can be seen in columns 3 and 4, when I enter the linear and the square term of regulation, neither of them is statistically significant. When each dimension is entered, only the ITU/Tenenbaum factor is positively associated with greater network deployment and statistically significant at standard levels (for the one-way effect). When lagged terms of privatization and competition are used as instruments, they are positive but statistically insignificant. There are no fundamental changes in the control variables.

The Sargan's test from the one-step homoskedastic estimate rejects the null hypothesis that the over-identifying restrictions are valid. However, as Arellano and Bond warn, this could be attributable to heteroskedasticity.[18] Recall that all t-statistics are heteroskedasticity-robust. The estimate coefficients in the homoskedastic case (not presented here) were all statistically significant and with the expected sign. I prefer to present the robust estimates. The null of first-order autocorrelation in the differenced residuals is rejected, but as Arellano and Bond (1991, 281) stress, ''The consistency of GMM estimators hinges heavily on the assumption that $E(\nu_{it}\nu_{i(t-2)}) = 0$'', so I cannot reject the null of no second-order autocorrelation.

Table 6 shows the GMM estimate coefficients when all telecom reform variables (regulation, privatization and competition) are assumed to be endogenous. The relationship between a better regulatory framework and telecom performance is verified. Entered alone, with its square term, or (in a lesser measure) with its three components, the

17 The results for the subsample of 12 low-income countries in the region were generally poor. The variables displayed the expected sign, but their statistical significant was low for the three new estimators.

18 Arellano and Bond found evidence that the one-step Sargan's test over-rejects in the presence of heteroskedasticity; see the last two panels of their table 3 (1991, 288).

Table 5. Parameter Estimate for Log of Teledensity

	Competition and Privatization as Endogenous GMM-One-Step					
Regressors	1	2	3	4	5	6
LogTeleden (− 1)	0.7988*	0.7602*	0.7776*	0.7410*	0.7973*	0.7593*
t	(12.8)	(13.2)	(11.8)	(12.5)	(12.4)	(13.0)
Regul (− 1)	0.07679**	0.07995**	− 1.89E-03	− 0.038		
t	(2.75)	(2.66)	(− 0.02)	(− 0.39)		
[Regul (− 1)]^2			6.92E-02	0.11255		
t			(0.82)	(1.21)		
Separation (− 1)					0.0153	0.0112
t					(0.86)	(0.52)
ITU/Ten (− 1)					0.0402	0.0553**
t					(1.53)	(2.13)
Legal (− 1)					0.0197	0.0129
t					(1.02)	(0.72)
Comp	0.0126	0.00997	0.0173	1.17E-02	0.0131	0.0102
t	(1.1)	(1.2)	(1.5)	(1.4)	(1.2)	(1.4)
Owner	0.0104	0.0112	1.53E-02	1.02E-02	0.0123	0.0111
t	(0.56)	(0.56)	(0.73)	(0.51)	(0.70)	(0.55)
GDPPC (− 1)	2.7E-05**	2.0E-05***	2.74E-05**	2.15E-05**	3.04E-05**	2.04E-05**
t	(2.06)	(1.77)	(2.40)	(2.02)	(2.43)	(1.96)
Trade (− 1)	5.5E-05**	2.9E-04	5.4E-04**	2.6E-04	5.1E-04**	2.9E-04
t	(2.5)	(1.05)	(2.45)	(0.99)	(2.29)	(1.06)
Density (− 1)	8.6E-04	9.74E-04**	1.09E-03	1.1E-03**	8.9E-04	9.7E-04***
t	(1.34)	(2.01)	(1.63)	(2.31)	(1.37)	(1.9)
Year dummies	Yes	No	Yes	No	Yes	No
Wald[a]	0.000	0.000	0.000	0.000	0.000	0.000
Serial correlation[b]	0.3708	0.4217	0.3544	0.4344	0.3916	0.4215
N-obs	352	352	352	352	352	352

Notes. The *t*-ratios in parentheses are robust to heteroskedasticity; *statistically significant at 1%, **statistically significant at 5%, and ***statistically significant at 10%.
[a] The *p*-value of Wald test of the null that all coefficients except the constant (and time dummies are zero.
[b] The *p*-value of a test for second-order serial correlation in the residuals of the difference equations.

effects of regulation on telecom performance are always positive. Depending on the specification used, competition and privatization are also positively associated with greater network deployment, although the results (as in the static case) are more compelling for one-way effect. All income and cost variables are also associated with better performance in telecommunications, as one should expect. Again, the lagged dependent variable is by far the most important factor explaining network deployment. It may show the importance of investment commitments by new private owners (in the past) and may be a proxy for government commitment, signaling where privatization can be implemented.

Sargan's and serial correlation tests replicate previous results. I again stress that the *t*-statistics are robust to heteroskedasticity and that in the homoskedastic case, the results

Table 6. Parameter Estimate for Log of Teledensity

	Regulation, Competition and Privatization as Endogenous GMM-One-Step							
Regressors	1	2	3	4	5	6	7	8
LogTeleden (− 1)	0.8009*	0.7860*	0.7828*	0.7920*	0.7811*	0.7755*	0.8047*	0.7973*
t	(14.65)	(13.36)	(13.1)	(15.56)	(13.59)	(14.58)	(15.4)	(14.78)
Regul (− 1)	0.0712**	0.069**	0.0605**	− 0.0511	− 0718	− 0.0818		
t	(2.57)	(2.51)	(2.11)	(− 0.68)	(− 89)	(− 1.03)		
[Regul (− 1)]^2				0.110	0.126	0.1355***		
t				(1.55)	(1.64)	(1.76)		
Separation (− 1)							0.0126	0.0101
t							(0.72)	(0.52)
ITU/Ten (− 1)							0.0428***	0.0418
t							(1.65)	(1.58)
Legal (− 1)							0.0166	0.0139
t							(0.95)	(0.84)
Comp	0.0127	0.0123	0.0143***	0.0138	0.0186**	0.0162**	0.0139	0.0154**
t	(1.34)	(1.53)	(1.71)	(1.49)	(2.40)	(2.09)	(1.56)	(1.99)
Owner	0.0094	0.0203	0.0219	0.0276**	0.0176	0.0183	0.0107	0.0163
t	(0.59)	(1.33)	(1.33)	(2.59)	(1.06)	(1.18)	(0.65)	(0.99)
GDPPC (− 1)	2.8E-05**	2.26E-05**	2.36E-05**	2.7E-05**	2.35E-05**	2.3E-05**	3E-05**	2.46E-05**
t	(2.53)	(2.28)	(2.26)	(2.59)	(2.68)	(2.7)	(3.27)	(2.80)
Trade (− 1)	4.9E-04**	3.4E-04	3.4E-04	4.2E-04**	2.95E-04	2.7E-04	4.1E-04**	3.15E-04***
t	(2.48)	(1.56)	(1.50)	(2.26)	(1.60)	(1.43)	(2.30)	(1.91)
Density (− 1)	7.6E-04	9.4E-04***	9.8E-04**	9.5E-04***	1.03E-03**	1.06E-03**	7.9E-04	8.9E-04***
t	(1.47)	(1.94)	(2.00)	(1.90)	(2.04)	(2.19)	(1.55)	(1.84)
Year dummies	Yes	No	No	Yes	No	No	Yes	No
Serial correlation [a]	0.3505	0.3880	0.3810	0.3897	0.3936	0.4011	0.3905	0.3963
Sargan Test [b]	0.000	0.000	0.000	0.000	0.000	0.000	0.0613	0.000
Wald [c]	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wald [d]	—	—	—	χ^2(2) 0.0168	χ^2(2) 0.0225	χ^2 (2) 0.030	χ^2(3) 0.0463	χ^2(3) 0.0485
N-obs.	352	352	352	352	352	352	352	352

Notes. The *t*-ratios in parentheses are robust to *heteroskedasticity.* *statistically significant at 1%, **statistically significant at 5%, and ***statistically significant at 10%.
[a] The *p*-value of a test for second-order serial correlation in the residuals of the differenced equations.
[b] The *p*-value of Sargan's test for overidentifying restrictions.
[c] The *p*-value of Wald test of the null that all coefficients except the constant (and time dummies are zero.
[d] The *p*-value of Wald test of joint significance of regulation variables.

(not presented) were all as expected. I remain with the robust estimates because the presence of heteroskedasticity is evident in the large difference in the standards errors. Additionally, the second Wald test shows the joint significance of the regulation variables (columns 4–8). In all cases, the *p*-values were highly significant, reinforcing the importance of a good regulatory framework. Although some results resemble those found either for the static or for the partial endogeneity models, the overall fit of the dynamic model and the almost global significance of all variables suggest that a dynamic specification is preferable to a static one. This model is far from perfect, but I wanted to offer a dynamic perspective of how telecom reform variables, especially regulation, may enhance particular performance outcomes.

7. Conclusion

This research sheds new light on the effects of telecommunications reform on performance variables like main lines per 100 inhabitants and the level of efficiency. The econometric results show that Latin American and Caribbean countries with a better regulatory framework will have greater network deployment. Competition and privatization (ownership) are associated positively with the level of network and with main lines per employee for the whole sample. Cost variables were also important. Although privatization is important, nothing was said about which aspects of privatization were the most relevant or to what extent different privatization procedures may have different effects on performance in the sector. For instance, it would be useful to know how the commitments of new telecom owners were implemented in the (privatization) contract and how the regulatory governance system provided investment incentives. Also, the dynamic model suggests that neglecting the effect of lagged dependent variables may distort or overestimate the effect of all the variables, including reform variables. Clearly, these results suggest that more research in this area is needed.[19]

Although the sample of countries chosen in this study is restricted to the Latin American region, the inferences may be valid for countries with some similarities. The main lesson is that the building of a sound and strong regulatory environment, the opening of the market to more competition and the free entry of private investors in basic telecommunications services will propel network expansion and efficiency across the sector.

19 The papers by D'Souza and Megginson (1999) and by Bortolotti et al. (2002) may be the exception. The former one compares the pre- and post-privatization performance of 85 firms, including 16 in telecommunications, in developed and developing countries. Telefónos de Mexico was the only Latin American telco included. The latter paper makes a thorough study of the financial and operating performance of 31 former state-owned telecom operators. The authors include a simple regulatory framework with competition and state ownership as variables (among others) and test their effect on profitability, output and efficiency. Only two Latin American countries, Argentina and Mexico were included in this study.

Research on telecommunications reform is still in process. I mostly assumed in the static context that the regulatory framework was exogenously determined. My dynamic model is also a first step in analyzing the determinants of telecom performance by considering regulation as an endogenous variable. Although the results were good, the regulatory framework index may be improved with the addition of new factors not yet recognized. Further work must be done to include in the RFI more aspects of regulatory incentives, especially those regarding price setting.

Additionally, as more information and data are accumulated at the firm level and more players enter the telecom market, more in-depth analyzes can be made to incorporate elements that are not captured by the ITU database since it may not collect information from all the new (small) operators. The papers by D'Souza and Megginson (1999), Bortolotti et al. (2002) and Dabler et al. (2002) are steps in this direction. Finally, new and more precise performance variables should be devised if firm-level data become available. Recently, work in this direction has started for European telecommunications (see Quiroz and Picaso 2001 and Boylaud and Nicoletti 2001).

In the future, more statistical information about the recent privatization of telecom operators in Central America and Brazil will provide additional observations. Also, concerns about convergence in telecommunications and the rapid growth of mobile telecommunications services complicate matters for research purposes. This study suggests lines of future research in the region and on the sector.

Appendix

Table A1. Sample Characteristics

	Mean	Std Dev	Min	Max	Median	1st Qrt	3rd Qrt
Teledensity	6.14	4.35	0.81	23.20	5.04	2.52	8.55
Efficiency	66.15	51.45	51.45	8.80	54.28	28.31	87.74
RFI[a]	0.380	0.251	0.143	1.00	0.286	0.143	0.571
Competition	0.308	0.462	0.00	1.00	0.00	0.00	1.00
Privatization	0.202	0.402	0.00	1.00	0.00	0.00	0.00
GDPPC[b]	2,426	1,730	416	8,955	1,809	1,330	3,348
TRADE	62.35	41.08	10.43	210.71	50.36	35.64	75.38
Density	59.90	75.74	2.28	286.09	29.34	15.05	57.72
Urban	59.70	16.31	30.50	90.70	56.42	46.49	71.69

[a] Regulatory framework Index.
[b] In 1995 U.S. dollars.

Table A2. Correlation Matrix

	Teledensity	Efficiency	RFI	GDPPC	TRADE	COMPET	PRIVAT	Density	Urban
Teledensity	1.000								
Efficiency	0.529	1.000							
RFI	0.381	0.552	1.000						
GDPPC	0.612	0.326	0.205	1.000					
TRADE	0.039	−0.162	0.097	−0.302	1.000				
Competition	0.290	0.560	0.494	0.160	−0.048	1.000			
Privatization	0.069	0.320	0.438	0.086	0.0760	0.318	1.000		
Density	0.049	−0.149	0.192	−0.064	0.170	−0.102	0.083	1.000	
Urban	0.540	0.450	0.316	0.762	−0.422	0.260	0.173	−0.192	1.000

Table A3. Main Variable Country Means[a]

	Teledensity	Efficiency	RFI	GDPPC	TRADE	COMPET	PRIVAT	Density	Urban
ARG	10.89	99.52	0.464	7,695	15.60	0.50	0.44	11.64	85.92
BOL	3.21	128.57	0.365	879	48.16	0.39	0.05	5.94	54.06
BRA	6.46	95.41	0.373	4,163	17.66	0.39	0.00	16.98	73.27
CHI	7.46	102.34	0.698	3,048	55.60	0.50	0.55	17.12	82.94
COL	7.57	108.64	0.444	1,802	31.08	0.22	0.00	32.80	68.95
COS	10.19	85.44	0.262	2,396	77.46	0.33	0.00	56.83	46.52
ECU	4.44	80.32	0.357	1,516	52.60	0.22	0.00	35.85	53.84
ESAL	2.81	25.77	0.190	1,450	52.09	0.28	0.00	246.21	43.54
GUA	2.04	37.74	0.333	1,415	38.48	0.44	0.00	78.61	38.12
GUY	3.16	35.05	0.516	667	155.22	0.33	0.39	4.06	33.05
HON	1.67	20.73	0.238	701	67.52	0.11	0.00	42.05	39.86
JAM	5.92	43.51	0.516	1,539	111.29	0.00	0.55	218.55	50.77
MEX	6.39	123.25	0.357	3,240	36.56	0.55	0.39	42.40	70.94
NIC	1.55	16.93	0.230	543	67.24	0.28	0.00	30.85	58.40
PAN	9.09	59.15	0.190	2,824	165.02	0.11	0.00	31.32	53.30
PAR	2.56	19.83	0.238	1,806	48.31	0.33	0.00	10.20	47.65
PER	2.90	66.98	0.444	2,462	29.93	0.44	1.00	16.33	68.25
RDOM	4.46	79.37	0.579	1,426	70.06	0.44	1.00	142.45	57.08
SUR	8.90	30.75	0.143	823	61.31	0.00	0.00	2.52	46.82
TRIT	12.09	52.55	0.706	4,380	78.68	0.00	0.00	236.03	68.10
URU	13.11	56.72	0.294	5,037	42.67	0.33	0.00	17.62	88.23
VEN	8.25	86.66	0.417	3,559	49.13	0.55	0.05	21.34	83.79

Source. (1) GDPPC, TRADE, Density and Urban were taken from the World Bank, ''Economic and Social Indicators 1999'' CD-ROM, (2) Teledensity and Efficiency were taken from the International Telecommunications Union (1997a) ITU Database World Telecommunications Indicators 1997, and (3) RFI, COMPET and PRIVAT were constructed by the author using different sources, among them ITU 1997b and 1998 (see Gutierrez 2002 for more details).

Table A4. Parameter Estimate for Log of Main Lines per 100 Inhabitants—12 countries

	Fixed Effects. All Main Variables as Exogenous		2SLS Fixed-Effect with Endogenous Competition and Privatization		Fixed Effects. All Main Variables as Exogenous	
Regressor	1	2	3	4	5	6
Regul (− 1)	0.24*	0.0045	0.128**	− 0.04	0.111***	− 0.041
t	(5.56)	(1.24)	(2.46)	(− 0.26)	(1.89)	(− 0.96)
Comp	0.093*	− 0.019	0.174*	0.043	0.061**	− 0.036***
t	(4.71)	(− 1.02)	(5.53)	(1.42)	(2.66)	(− 1.79)
Owner	0.161*	0.09*	0.207*	0.14*	0.017	− 0.031
t	(4.27)	(2.95)	(5.35)	(4.57)	(0.32)	(− 0.64)
Regul*Comp (− 1)					0.13**	0.09**
t					(2.63)	(2.22)
Regul*Owner (− 1)					0.302	0.254
t					(4.08)*	(3.93*)
GDPPC (− 1)	5.7E-05	1.6–05*	8E-05	1.8E-04**	3.5E-05	1.4E-04**
t	(0.95)	(3.45)	(1.38)	(4.25)	(0.59)	(3.34)
Trade (− 1)	− 7.0E-04	1.8E-05	− 9.2E-04	− 5.7E-05	− 1.1E-03**	− 2.0E-04
t	(− 1.32)	(0.57)	(− 0.19)	(− 0.19)	(− 2.2)	(− 0.67)
Density (− 1)	0.011*	0.005*	0.009*	0.004*	0.011*	0.005*
t	(9.3)	(5.4)	(7.45)	(5.39)	(5.8)	(9.8)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	No	Yes	No	Yes
R-sqr	0.923	0.961	0.916	0.957	0.9672	0.9317
Hausman[a]	129.15*	21.43*			428.54*	32.071*
N	204	204	204	204	204	204
Instruments used in Logit regressions (aside from main regressors above)	—	—	Civil and political liberties indexes, and FDI/GDP	Civil and political liberties indexes, and FDI/GDP	—	—

Notes. The *t*-ratios in parentheses are robust to heteroskedasticity; *statistically significant at 1%, **statistically significant at 5%, and ***statistically significant at 10%.
[a] Hausman test of Ho: Random-effects vs fixed-effects.

Table A5. Parameter Estimate for Log of Main Lines per 100 Inhabitants—12 countries

	Fixed Effects. All Main Variables as Exogenous		2SLS Fixed-Effect with Endogenous Competition and Privatization		Fixed Effects. All Main Variables as Exogenous		2SLS Fixed-Effect with Endogenous Competition and Privatization	
Regressors	1	2	3	4	5	6	7	8
Regul (−1)	−0.013	−0.283***	−0.049	−0.242***				
t	(−0.05)	(−1.88)	(−0.23)	(−1.95)				
[Regul (−1)]^2	0.2474	0.3206**	0.173	0.225***				
t	(1.05)	(2.12)	(0.88)	(1.78)				
Separation (−1)					−0.016	0.018	−0.0021	0.014
t					(−0.26)	(0.41)	(−0.36)	(0.36)
ITU/Ten (−1)					0.13***	0.05	0.097	0.027
t					(1.76)	(0.98)	(1.48)	(0.59)
Legal (−1)					0.096	−0.014	0.077	−0.023
t					(1.38)	(−0.27)	(1.00)	(−0.43)
Comp	0.092*	−0.024	0.171*	−0.002	0.092*	−0.020	0.13*	0.014
t	(4.74)	(−1.26)	(5.34)	(−0.13)	(4.65)	(−1.06)	(4.33)	(0.49)
Owner	0.153*	0.081**	0.206*	0.089*	0.153*	0.092**	0.203*	0.137*
t	(4.14)	(2.63)	(5.4)	(4.28)	(4.0)	(3.32)	(5.57)	(5.03)
GDPPC (−1)	3.5E-05	1.2E-04**	6.4E-05	7E-05*	4.3E-05	1.6E-04**	5.1E-05	1.7E-04**
t	(0.53)	(2.4)	(1.03)	(5.42)	(0.57)	(2.78)	(0.7)	(2.99)
Trade (−1)	−7E-04	1.7E-04	−9.3E-04	−7.5E-05	−6.6E-04	−1.8E-04	−8.2E-04	1.4E-04
t	(−1.32)	(0.56)	(−0.19)	(−0.25)	(−1.19)	(−0.56)	(−0.16)	(0.04)
Density (−1)	0.011*	0.005*	0.01*	0.005*	0.011*	0.005*	0.01*	0.004*
t	(10.5)	(6.7)	(7.99)	(6.27)	(9.6)	(5.16)	(8.92)	(5.36)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	No	Yes	No	Yes	No	Yes
R-sqr	0.9232	0.9622	0.9163	0.9586	0.9233	0.9608	0.9210	0.9594
Hausman[a]	468.72*	77.07*			3.27	49.74*		
N-obs.	204	204	204	204	204	204	204	204

Notes. The *t*-ratios in parentheses are robust to heteroskedasticity; *statistically significant at 1%, **statistically significant at 5%, and ***statistically significant at 10%.
[a] Hausman test of Ho: Random-effects vs fixed-effects.

Table A6. Parameter Estimate for Log of Efficiency—12 countries

Regressors	Fixed Effects. All Main Variables as Exogenous							
	1	2	3	4	5	6	7	8
Regul (− 1)	0.486*	0.229*	0.360*	0.173**	0.336	− 0.144		
t	(7.92)	(4.0)	(4.08)	(3.07)	(1.19)	(− 0.59)		
[Regul (− 1)]^2					0.1468	0.3646		
t					(0.54)	(1.62)		
Separation (− 1)							0.050	0.0745
t							(0.81)	(1.58)
ITU/Ten (− 1)							0.152***	0.0786
t							(1.93)	(1.52)
Legal (− 1)							0.1876**	0.044
t							(2.98)	(1.02)
Regul*Comp (− 1)			0.354*	0.296*				
t			(4.25)	(4.27)				
Regul*Owner (− 1)			0.121	0.040				
t			(1.46)	(0.77)				
Comp	0.118*	− 0.024	0.087**	− 0.028	0.117**	− 0.03	0.1111*	− 0.025
t	(4.73)	(− 1.17)	(2.68)	(− 1.17)	(4.67)	(− 1.48)	(4.51)	(− 1.18)
Owner	0.086**	0.031	0.354*	− 0.114**	0.082***	0.020	0.076***	0.031
t	(1.96)	(0.83)	(4.25)	(− 2.5)	(1.85)	(0.57)	(1.67)	(0.87)
GDPPC (− 1)	− 1.4E-05	− 2.5E-05	− 3.7E-05	− 4.34E-05	− 2.67E-05	− 7.47E-04	2.86E-05	3.36E-05
t	(− 0.18)	(− 0.33)	(− 0.48)	(− 0.56)	(− 0.32)	(− 0.88)	(0.33)	(0.39)
Trade (− 1)	− 4.7E-04	5.4E-04	− 9E-04***	1.38E-04	− 4.65E-04	5.28E-04	− 5.6E-04	4.425E-04
t	(− 0.85)	(1.61)	(− 1.79)	(0.46)	(− 0.32)	(1.58)	(− 1.02)	(1.33)
Density (− 1)	0.008*	0.002	0.008*	0.002	0.008*	0.031	0.008*	0.001
t	(7.39)	(0.83)	(8.13)	(0.79)	(7.13)	(0.82)	(7.15)	(1.23)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	No	Yes	No	Yes	No	Yes
R-sqr	0.9157	0.9531	0.923	0.9577	0.9154	0.9539	0.9187	0.9534
Hausman[a]	72.53*	80.39*	62.41*	18.32**	63.90*	120.04*	678.56*	99.694
N-obs	204	204	204	204	204	204	204	204

Note. The t-ratios in parentheses are robust to heteroskedasticity; *statistically significant at 1%, **statistically significant at 5%, and ***statistically significant at 10%.
[a] Hausman test of Ho: Random-effects vs fixed-effects.

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