

# **The Impact of Privatization and Competition in the Telecommunications Sector around the World**

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**Abstract.** Using a comprehensive country-level panel data set covering the period from 1981 to 1998, we examine the impact of privatization and competition in the telecommunications sector around the world. Privatization contributed substantially to labor shedding, output growth, network expansion, and improvements in labor productivity as well as total factor productivity. But how countries privatized is important. Share issue privatization facilitated the development of the mobile market segment. Granting a newly privatized operator a period of exclusive market access, on the other hand, reduced the gains from privatization (due to the output-restricting tendency associated with market power) but not entirely negated the gains. The presence of competitive pressure in the market was associated with more employment, higher output, faster network expansion, and higher labor and total factor productivity. We find evidence of complementarity between privatization and competition in that competition increased the gains from privatization and vice versa. Our estimates show that half of the output growth between 1990 and 1998 was attributable to privatization and competition after controlling for input growth. Competition appeared to have a larger impact on labor and total factor productivity than privatization.

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## 1. Introduction

Until recently in most countries, telecommunications service providers were state-owned, state-operated, and often operated in protected monopolistic markets (Noll, 1999). With the privatization of British Telecom and the introduction of competition in the U.S. long-distance telephone services, the late 1980s and 1990s witnessed the most dramatic policy reforms the telecommunications world had ever seen.<sup>2</sup> National carriers were privatized, new competitors licensed, and new services allowed. More than 150 countries introduced new telecommunications legislation or modified existing regulations. In 1980, only two percent of telecommunications operators in 167 countries had private owners. By 1998, as we shall see later in the paper, the number increased to 42 percent. The privatization trend was part of a global movement towards liberalization in this sector as countries introduced competition in this sector, especially in the mobile telecommunications segment. The monopoly-based system of service supply, which dominated the world's telecommunications markets for over three-quarters of the last century, gave way to competitive supply in many markets.

Though there has been much theoretical and empirical research on the effects of privatization and competition in infrastructure in general, relatively little empirical work has been done on how the designs of privatization and competition policies affect performance and how components of these policies interact with each other in shaping the reform outcomes. For instance, how does granting a privatized monopoly operator a period of exclusive access to a certain market segment affect productivity? Does the effect of privatization depend on whether privatization is done through public share issuance? Is privatization (or competition) alone sufficient in improving productivity? Are privatization and competition complements? And finally, how do privatization and competition affect the sector's performance as measured by a broad list of economic indicators, including total factor productivity?

In this paper we study the impact of privatization and competition on employment, investment, output, network expansion in both fixed-line and mobile market segments,

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<sup>2</sup> Factual information in this Section is drawn from reports published by the International Telecommunications Union (ITU, 1999a, 1999b) and Pyramid Research (2000).

labor productivity, and total factor productivity in the telecommunications sector around the world. The data we use are comprehensive in coverage: they contain information on privatization from 166 countries between 1981 and 1998 and information on competition from 43 countries between 1990 and 1998. Our analyses of the data show that privatization and competition had a large positive impact on telecommunications performance. Privatization in general contributed substantially to labor shedding, output growth, network expansion, and improvements in labor productivity as well as total factor productivity. But how countries privatized is important. Share issue privatization is found to facilitate the development of the mobile market segment. Granting a newly privatized operator a period of exclusive access to some market segments, on the other hand, tends to reduce the size of the gains from privatization but not entirely negate the gains. The presence of competitive pressure in the market is associated with more employment, higher output, faster network expansion, and higher labor and total factor productivity. We find evidence of complementarity between privatization and competition in that having both would bring much more gains than having just one. Our estimates show that half of the output growth between 1990 and 1998 is attributable to privatization and competition after controlling for input growth. Competition appeared to have a larger impact on labor and total factor productivity than privatization.

This paper differs from others in the literature on the effects of telecommunications reforms.<sup>3</sup> To begin with, our sample has a wider coverage and contains more information on telecommunications reforms than most existing studies.<sup>4</sup> For instance, Ros (1999) examines a sample of 110 countries, and his measures of telecommunications reforms include ownership and competition as measured by the number of mobile phones. Wallsten (2001) uses data from 30 developing countries and his reform variables include privatization dummies and the number of mobile competitors as a proxy for competition.<sup>5</sup>

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<sup>3</sup> For a nice summary of existing studies on telecommunications reforms, see Noll (1999); Bortolotti, D'Souza, Fantini, and Megginson (2001); and Wallsten (2001).

<sup>4</sup> Besides the econometric analysis we summarize here, there are also many important case studies on the effects of reforms on the telecommunications sector. They include Levy and Spiller (1996); Kikeri, Nellis and Shirley (1992); Petrazzini (1995); Ramamurtri (1996); Roth (1987); and Wellenius and Stern (1994).

<sup>5</sup> Wallsten (2000) examines the effects of exclusivity to 20 privatized telecoms in 15 countries and finds that exclusivity periods reduce telecommunications capacity and investment incentives. This offers thus further support for the importance of competition.

Boylaud and Nicoletti (2000), focusing on the subset of 23 OECD countries in the 1990s, find that privatization had little effect, while competition helped improve service quality. Petrazzini and Clark (1996) find that in a sample of 26 developing countries, deregulation and privatization increased tele-density. Bortolotti, D'Souza, Fantini, and Megginson (2001) look at 25 countries and focus on the impact of a specific type of privatization -- share issue privatization. Fink, Mattoo and Rathindran (2002) examine the sample of developing countries. More comparable in data to our analysis, McNary (2001) covers over 200 countries between 1987 and 1998 and considers the effects on network penetration from privatization and competition for both fixed and mobile phone segments.

More important, unlike most existing studies, we also consider the details of privatization and competition in the analysis, not just the privatization dummy and the competition associated with the number of mobile phone subscribers or service providers. There are a few exceptions. Wallsten (2000) considers the effects of exclusivity on revenue raised from privatization and on tele-density, while McNary (2001) and Fink et al (2002) examine the effects of competition. We also consider the effects of exclusivity; but we consider the effects on a wider set of behavioral and performance measures. We also consider the effects of competition; but instead of using of dummy variables, our measures of competition incorporate more information in both fixed and mobile phone segments. Moreover, unlike others in the literature, we consider explicitly non-state ownership share, and the relative impacts of share-issue privatization and non-share-issue privatization. Our comprehensive data also allow us to examine a wider set of performance indicators, including employment, output, network expansion in both fixed and mobile telephone segments, labor productivity, and total factor productivity.

And finally, given the relative comprehensive coverage of both privatized and non-privatized countries, our study avoids the sample selection biases that might have affected the results in previous studies that used samples consisting exclusively of privatized firms or countries. To the extent that performance was one of the criteria in deciding whether a country or a telecommunications firm in the country should privatize, the sample of privatized countries or firms would not be random, and estimates of the effects of privatization based on such a sample would be biased.

Our focus on the telecommunications industry to study the impact of privatization and competition is not without merits. The telecommunications industry is one of the fastest growing sectors in most countries. Currently its service revenue alone, equipment sales not included, accounts for approximately two to three percent of GDP in most countries (Li and Xu, 2002). The sector is believed to offer substantial positive externalities to other industries by, among other things, reducing transaction costs for businesses. Indeed, Roller and Waverman (2001) have found a positive linkage between a country's telecommunications infrastructure and its economic growth. Given the sector's economic and technological importance, its privatization and liberalization have often been controversial. It is no surprise that countries often use privatization and liberalization in this sector as a signal to the international community of their seriousness about instituting pro-market reforms. According to Bortolotti et al. (2001), telecommunications share-issue privatization almost always represents the largest share offerings in many countries, and telecommunications stocks often are the "bellweather" stocks on national exchanges. It is therefore our view that this sector provides a good context for studying the effects of privatization and competition.

Ideally the study of the effects of privatization and competition should be based on firm-level data. But such data are hard to come by. For instance, it is fairly difficult to measure the competitive pressure that each individual firm faces.<sup>6</sup> The telecommunications sector offers a convenient setting since the industry tends to be dominated by a very small number of players in any given country. As a result, the distinction between country-level and firm-level data in telecommunications industry is not as significant as in many other industries.

The rest of the paper is organized as follows. Section 2 reviews the literature on how privatization and competition might affect performance in the telecommunications sector. Section 3 describes the available data. Section 4 discusses our choice of empirical specifications and presents the results. Section 5 gives some concluding remarks.

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<sup>6</sup> Two exceptions of directly measured competition at the firm level are Nickell (1996) and Li (1997).

## 2. Analytical Framework

There is a large body of literature on how privatization (in comparison with the status quo of state ownership) and product market competition affect the efficiency of an enterprise.<sup>7</sup> Previous theoretical and empirical work has shown that the relationship between ownership and product market competition, on the one hand, and the allocative and productive efficiency of the affected firm on the other, are complex. Liberalization reforms that change ownership and market structure affect the firm's performance through multiple channels. Below we consider in turn how the reforms can alter the firm's objectives, reduce bureaucratic intervention, and realign managerial incentives.

A firm under public ownership is often under direct bureaucratic control. Politicians who control the firm often choose not to maximize the firm's profit, which is owned by the public and controlled by the treasury. While a benevolent and selfless politician may maximize social welfare, most politicians will give weights in their objective function to patronage motives—redistribution preference to favored interest groups, subsidization of loss-making public enterprises, and excessive wage and employment in public sectors (Lopez-de-Silanes, Shleifer, and Vishny, 1997; Shleifer and Vishny, 1994, 1998; and Noll, 1999). Noll's (1999) argument, listed below, focuses on the telecommunications sector.

[N]ationalized telephone companies typically employed far more workers than were necessary. Employment per unit of output was extremely high, even after adjusting for the lower productivity of workers in poor countries. One cause was the use of nationalized enterprise for patronage, but another cause was the perverse incentive structure that the budget process created for managers of nationalized entities. Whereas the budgetary process could starve capital investment funds without much short-term consequence, it could not starve operating funds to pay salaries without creating an immediate political backlash. Hence, the budget process gave managers an incentive to substitute labor for capital, which, in a capital-intensive industry like telecommunications, is extremely inefficient.

Privatization, which transfers both the control rights and the residual cash-flow rights to private owners, should in principle increase labor productivity and improve input allocation in the absence of government intervention. However, private firms do frequently

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<sup>7</sup> See Vickers and Yarrow (1998), World Bank (1995), Shleifer (1996, 1998), and Megginson and Netter (2001) for excellent summaries of this theoretical and empirical literature.

face government intervention. But it is likely that private firms will face less government intervention than public ones. Sappington and Stiglitz (1987) argue that privatization increases the transaction costs of government intervention in firm decision-making. While privatization does not imply that politicians will not increase employment beyond the profit-maximizing level or subsidize loss-making firms, excessive employment and subsidization are clearly easier under public ownership.

Privatization can also affect the monitoring of managerial efforts. Given politicians' lack of profit motives, it is not surprising that managers of public enterprises face less incentive to reduce costs since they cannot capture the cost savings directly. In general, politicians may lack strong incentives to monitor enterprise management, as Vickers and Yarrow (1991) argue, if their political fortunes are not very sensitive to the overall performance of state-owned enterprises. Under private ownership, managers may face stronger incentives to reduce costs and to innovate. Because of the higher incentives to innovate and to save costs, we expect the telecommunications sector to have higher total factor productivity after privatization.

Other benefits of privatization are associated with the public listing of ownership shares on stock markets. The telecommunications firms are primary candidates for public listing in stock markets (Bortolotti, D'Souza, Fantini, and Megginson, 2001). In fact, this sector has witnessed some of the largest share issue privatization. Listing leads to two important benefits. First, listing provides alternative, and arguably better, sources of information for shareholders to monitor managerial performance, which in turn allows the use of high-powered incentives that are difficult to use without access to such information (Holmstrom and Tirole, 1989). Second, an important source of the inefficiency of the state-owned telecommunications sector is the lack of funds to upgrade the technology, an issue exacerbated by the protectionist tariffs, currency controls, and regional trade preferences for neighboring high-cost producers (Noll 1999). Share issue privatization allows instant access to funds provided by international and domestic investors.

There are, however, qualifications to the benefits of privatization. It has been argued that when there are externalities and economies of scale and scope, privatization might worsen performance without proper regulation to internalize the externalities or increase productivity and profitability at the expense of neglecting non-profit objectives

(such as universal service). But rapid technological innovations in the past three decades have significantly reduced economies of scale and scope in this sector, attenuating the economic rationale for state-owned natural monopoly in the telecommunications sector (Noll, 1999). In addition, externalities and universal services may be handled by regulation. For instance, the regulator can require private operators to fulfill certain universal service goals, which would likely be fulfilled since the more efficient private operators would have deeper pockets. Indeed Wallsten (2001b) finds evidence that private operators were better providers of universal services than public operators during the early last century.

More important, privatization without a simultaneous introduction of competition will simply create private monopolies interested in extracting monopoly rents by restricting output. Most economists therefore argue that privatization works best where there is competition limiting the market power of the incumbent(s) (see for example Yarrow (1986), Kay and Thompson (1986), and Vickers and Yarrow (1998)). Competition is thus seen as a complement to privatization.

Competition can be a force that affects—and most likely improves—performance in its own right.<sup>8</sup> To begin with, market competition tends to weed out inefficient firms under the assumption that firms face hard budget constraints. The ex ante threat of bankruptcy may compel existing operators to be leaner and more efficient so as to minimize the probability of a corporate failure. Since state-owned firms rarely operate under hard budget constraints, the positive impact of market competition on performance is more likely to be present in privatized firms, further suggesting a complementarity between privatization and competition.

Competition also makes it possible for the principal of a telecommunications service provider and the regulator to compare the firm's performance against that of its competitors. With more information to infer managerial efforts, the principal can write a better incentive contract for the managers, and the regulator can design and implement regulations more efficiently and more transparently (Holmstrom, 1982b; Nalebuff and Stiglitz, 1983; Hart, 1983). Performance is therefore expected to improve with competition.



In addition, as market competition makes managerial efforts more observable, managers should face added incentives from the managerial labor market to improve firm performance so as to protect their reputation and human capital (Holmstrom, 1982a; Meyer and Vickers, 1995).

Not every model of competition, however, predicts productivity improvement.<sup>9</sup> Schumpeter, for instance, suggests that firms with more market power face less uncertainty, have a larger cash flow, and can fund R&D and innovations more readily (see also Levin, Cohen, and Mowery, 1985). But in countries that have developed and sophisticated financial markets, new entrants may be able to fund the development and the adoption of new technology. To the extent that new entrants are more likely to adopt new and cheaper technologies and the incumbent has ample stranded assets in old technology, competition is likely to change the composition of the sector in favor of new technology, and therefore leads to higher productivity.

Our review thus far suggests that while there is a strong presumption that privatization and competition in the telecommunications sector improve economic performance, there remain significant qualifications. Whether this presumption is true remains largely an empirical question, to which we now turn.

### **3. Data**

Our empirical work relies on several major sources of data. Data on whether a country allowed private equity participation in its telecommunications sector, or the *Privatization* dummy variable, come from the World Bank. The privatization dummy variable is one for a country in a particular year if private investors hold ownership shares in the country's telecommunications sector, and zero otherwise. More detailed information on changes in ownership structure in the telecommunications sector come from the World Bank-Stanford dataset on telecommunications reforms. From this dataset, we construct the following two

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<sup>8</sup> See Nickell (1996) for a thorough summary of the effects of competition on performance; he also finds positive effects of competition on performance. Even for state-owned enterprises, there is evidence that competition is one of the most important determinants of performance (Li, 1997, and Xu, 2000).

<sup>9</sup> Hermanlin (1992), Martin (1993), and Horn, Lang, and Lundgren (1994) also present models in which the effect of competition is either ambiguous or even negative. See also a summary presented in Nickell (1996).

variables: the share of non-state ownership of the incumbent operators (*Non-state\_Share*), and a dummy variable indicating whether the country granted privatized operator(s) a period of exclusive access to certain market segments (*Exclusivity*). Following Megginson and Netter (2001), we also include a dummy variable that indicates whether privatization was done through a public share offering (*Share Issue Privatization* or *SIP*). Based on data in Bortolotti et al. (2001), the dummy variable *SIP* equals one when the incumbent operator is privatized through share issue privatization and zero otherwise.

Our competition variables come from the World Bank-Stanford dataset. For the period between 1990 and 1998, we have data on the number of fixed phone operators (*NFixed*) and the number of mobile phone operators (*NMobile*) in a particular country. But we do not have data on operators' market behavior to come up with a conduct-based measure of the intensity of competition. While we shall include both variables as indicators of competition, we also construct a composite competition indicator, *CompFirm*, as a geometric average of *Nfixed* and *NMobile*,<sup>10</sup> and use *CompFirm* in some more parsimonious specifications. *CompFirm* is observed in 43 countries. A list of countries with available data is available for the authors upon request.

In Table 1, we list some sample statistics of the privatization and competition variables. Of the 166 countries in our sample, less than 11% had non-state equity participation in the telecommunications sector in 1990; by 1998, over 42% of the countries had. Of all countries that privatized in 1998, about one-third offered investors exclusive access to certain market segments (exclusivity provisions), and one-third used public share offerings in the privatization. Based on data that are only available from 43 countries, the average share of non-state ownership in 1998 was 49%, up from 11.4% in 1990. Changes in the industrial organization in this sector were equally dramatic. The number of fixed phone operators rose sharply from 1.8 to 4.2 between 1990 and 1998, while the average number of mobile phone operators jumped from 0.6 to 2.6 during the same period.

In the upper panel of Table 2, we list the set of available variables that describe the conduct and performance of the telecommunications sector and their sample statistics. These variables are from International Telecommunications Union (ITU). Given our

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<sup>10</sup>  $CompFirm = 0.71 * \ln(1 + NMobile) + 0.71 * \ln(1 + NFixed)$ , constructed as the principal component of the two right-hand-side variables

interests in testing whether privatization reduces patronage, we include employment ( $L$ ) in this sector as a dependent variable. To construct an index measure of the real output ( $Q$ ) in the sector, we divide the reported total revenue by the cost of a 3-minute local phone call.<sup>11</sup> Labor productivity is then defined as the real output divided by employment or  $Q/L$ . Given the lack of telecommunications infrastructure in many developing countries, one of the main yardsticks in measuring the success of telecommunications reforms is the pace of network and services expansion. For our analysis, we include the size of capital investment in the telecommunications sector per capita (*Investment per capita*, measured in 1998 U.S.\$ using market exchange rates), the number of fixed phone lines per 100 inhabitants (*FixedDensity*), and the number of mobile phone lines per 100 inhabitants (*MobileDensity*) as dependent variables. Another important performance measure, the total factor productivity, which will be constructed later in the paper, will also be included in the analysis. In the lower panel of Table 2, we also report the sample statistics of the control variables that we use in the analysis.

The sample statistics in Table 2 show that most of the dynamics in the telecommunications sector around the world was in the mobile phone segment. While the number of fixed phone lines grew at only 2.4% per annum between 1990 and 1998, the number of mobile phone lines raced at a breakneck pace of nearly 28.4% per annum. The real output in this sector also grew at a remarkable 9.2% per annum between 1990 and 1998. Since this growth record was achieved during a period of labor shedding, rapid improvement in labor productivity in this sector was a major contributor to the sector's expansion. In what follows, we analyze whether these observed changes in performance can be attributed to privatization or competition or both.

#### **4. The Impact of Privatization and Competition**

The analysis in this section is divided into four parts. First, we compare the pre- and post-privatization performance of the telecommunications sector in countries that experienced full or partial privatization between 1981 and 1998. Second, we estimate the conditional effects of privatization and competition using multivariate regressions that control for

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<sup>11</sup> We do not have data on the breakdown of revenue into fixed line and mobile segments.

country-specific fixed effects as well as time-variant country characteristics. Third, we examine the impact of privatization and competition on labor productivity and on total factor productivity. And finally, we account for the contribution of privatization and competition to the changes in performance over time.

#### **4.1. Pre- and Post-privatization Comparison**

We employ a method similar to the matched pairs methodology used in Megginson et al (1994) for comparing the pre- and post-privatization conduct and performance of a subsample of countries that experienced full or partial privatization of their telecommunications sectors.<sup>12</sup> To test the implications of privatization discussed in Section 2, we calculate the mean of each of the conduct and performance variables for each country over the pre- and post-privatization periods as demarcated by the privatization dummy. We then calculate the difference between pre- and post-privatization means and test whether the difference is zero. In Table 3, we report the results.

Subject to qualifications to be discussed below, Table 3 shows that privatization was associated with a substantial reduction in employment, nearly 50 percent.<sup>13</sup> This is consistent with the prediction that privatization reduces patronage which has been blamed for creating a bloated work force in state-owned firms. In contrast, investment in the telecommunications sector rose sharply after privatization. There was clearly a large increase in capital intensity in this sector in the past two decades. Interestingly, privatization was also associated with a 38% reduction in real output. This is in part consistent with the patronage theory which asserts that politicians have an incentive to pressure state-owned telecommunications providers to subsidize basic services. It is also consistent with the prediction that privatized firms with market power have an incentive to restrict output if privatization gives them more operating autonomy. Given the much larger reduction in employment than in real output among privatized firms, it is not surprising that privatization was associated with a significant increase in labor productivity by 42

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<sup>12</sup> The main difference between our method and that of Megginson et al (1994) is that we do not restrict our sample to include only countries that have at least three years of pre- and post-privatization experience.

<sup>13</sup> The percentage change, which equals  $e^{-0.689} - 1$ , is obtained from the estimated change in log value of -0.689. The remaining percentage changes discussed in this paragraph are obtained the same way.

percent. In contrast to the fall in real output, we find that privatization was associated with a rapid expansion of the telephone network. Tele-density in both fixed and mobile lines rose sharply after privatization. The estimates here thus suggest that privatization was associated with a rapid expansion of service networks but a decline in the network usage per subscriber.

The findings, while consistent with the predictions made in Section 3, are certainly not without qualifications. First, by restricting the sample countries to those with privatization experience, the results reported in Table 3 may be affected by selection biases as discussed in the Introduction. Second, analyzing the impact of privatization only, the results in Table 3 may be affected by omitted variables biases. This is particularly likely since competition, which is expected to have significant impact on performance in its own right, was often introduced simultaneously with privatization. Indeed as we shall see later, the negative association between privatization and output is not robust when we use all available data in the full sample and control for additional explanatory variables. To avoid these potential biases, we use the full sample to jointly examine the impact of privatization and competition using fixed-effects multivariate regressions.

## 4.2. Conditional Effects

We first examine how privatization and competition affected employment, investment, real output, fixed-line density, and mobile density. The empirical specification we shall estimate is a fixed-effects treatment-response equation:

$$y_{it} = \mathbf{g}' R_{it} + \mathbf{b}' X_{it} + \alpha t + \mathbf{f}_i + \mathbf{e}_{it} \quad (1)$$

Where  $y$  is one of the outcome measures,  $R$  represents a vector of telecommunications reforms, and  $X$  a vector of control variables. The treatment-response specification estimates the effects of privatization and competition conditional on country-specific effects, a time trend, and a set of control variables.

By using a fixed-effects model, we control for country-specific heterogeneity, which might influence both policy changes and the telecommunications performance. Without controlling for country-specific effects, country heterogeneity can result in inconsistent estimates of reform effects. We include a time trend in the specification to

capture the effects of technological innovation, which are expected to be significant given the rapid adoption of new technology in this sector around the world. In our estimation, we also include the following time-invariant control variables: per capita income, population, and the degree of urbanization.<sup>14</sup> Since these variables affect the demand for telecommunications services in a country, they are expected to affect telecommunications outcomes.

Estimates of equation (1) based on various variations in the specification for each of the following five outcome variables, employment, investment, real output, fixed-line density and mobile density, are reported in Tables 4-10. In each regression, all available observations are used. We indicate the sample size for each regression in the Tables. Below we discuss these results in turn.

**Employment.** Table 4a presents estimates of the fixed-effects treatment-response equation with log employment as the dependent variable and without including any of the control variables listed in the lower panel of Table 2. Country-specific effects and a time trend, captured by the variable, *year*, are included in all regressions reported in Table 4a.

Inspection of the estimates suggests that full or partial privatization as captured by the privatization dummy reduces log employment by a statistically significant 0.168 (Column (1)). The degree of private equity participation in this sector also matters. An increase in non-state ownership by 10 percentage point is associated with 2.3 percentage point reduction in log employment (Column (2)). This implies that the effect of a full privatization on employment should be significantly higher than that of a partial privatization. These findings offer strong empirical support for the patronage theory outlined in Section 2.

Not all countries privatized in the same way. Significant cross-country differences exist in the design and implementation of privatization. In this paper, we have data on three variables that measure the differences. The first variable is *Non-state share*, which we used

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<sup>14</sup> We also conducted a series of robustness tests of the above specification by adding additional control variables including trade orientation, ICRG index on the risk of expropriation, and the size of economic aid received over GDP. We found that our reported results of the reform effects remained qualitatively similar, and that these additional control variables were largely statistically insignificant. As a result, we shall not report estimates of these alternative regression specifications. These additional regression results are available from the authors upon request.

in the regression in Column (2). The second variable is *Exclusivity*, a dummy variable indicating whether the government granted privatized operators exclusive access to certain market segments for a pre-determined period of time. The third variable is *SIP*, a dummy variable indicating whether the privatization was done through public share offerings. When we include only the privatization dummy (or the non-state ownership share) with either *Exclusivity* or *SIP* in the regression, *Exclusivity* and *SIP* do not have a robust effect on employment (Columns (3)-(6)). This lack of robustness is further demonstrated in Column (11), where we find that both *Exclusivity* and *SIP* are insignificant.

In contrast, competition increases employment. Estimates in Column (7) suggest that a one-standard-deviation increase in the competition index, *CompFirm*, would increase log employment by 4.5 percentage points (i.e.,  $0.038 \times 1.18$ ). In Column (8), we include the two original competition variables—the number of fixed phone operators and the number of mobile phone operators (in logarithm)—to estimate their separate effects. The results suggest that the employment-expanding effect of competition is due mainly to intensified competition in the fixed-line market segment.

To investigate the joint impact of privatization and competition on employment, we include both variables in the regression and report the results in Columns (9)-(11). Notice that only 40 countries have available data on both *Privatization* and *CompFirm*. While estimated effects of privatization and competition are righted-signed, they are not statistically significant. Estimates of the coefficient on the interaction variable between *Privatization* and *CompFirm* are small and statistically insignificant. The offsetting effects of privatization and competition on employment appears to cancel each other when the two reforms are introduced simultaneously.

To check the robustness of the estimates reported in Table 4a, we include in the regressions the three control variables defined in Table 2, which capture factors that affect demand for telecommunications services. The new estimates are reported in Table 4b. To the extent that the control variables are correlated with the reform variables, which seem likely, the estimates in Table 4a are likely affected by omitted-variables biases, while the estimates in Table 4b should be free from these omitted variables biases.

The inclusion of the three control variables does improve the explanatory power of the regression model as can be seen by the increases in the R-squared from Table 4a. A

strong positive association exists between *Urbanization* and *Employment*, while the relation between *Employment* and *Population* or *GDP per capita* is weaker and less robust to changes in specifications. It is interesting to note that estimates of the coefficient on the time trend variable, *year*, are all negative and statistically significant in Table 4b. A plausible interpretation of this result is that most of the new technologies adopted between 1981 and 1998 were of the labor-saving kind.

But comparison of the estimates in Tables 4a and 4b reveals that the inclusion of control variables does not change the estimates of the effects of privatization and competition qualitatively. The conclusions that we reached based on results in Table 4a remain valid when control variables are added. The anticipated omitted variable biases thus seem inconsequential. We also tried including additional control variables in the regressions and found that our estimates in Table 4a were robust to these changes in specification (see footnote 14).

***Investment.*** To estimate the effects of privatization and competition on investment in the telecommunications sector, we run fixed-effects regression on equation (1) under various specifications with log investment per capita as the dependent variable. We report in Table 5 only the estimates based on specifications that do not include the control variables because the inclusion of the control variables does not alter our qualitative results.

Inspection of the estimates suggests that full or partial privatization increases log investment per capita by a statistically significant 0.233 (Column (1)). The degree of private equity participation in this sector also matters. An increase in non-state ownership by 10 percentage point is associated with 12 percentage point increase in log investment (Column (2)). This implies that the effect of a full privatization on investment should be significantly higher than that of a partial privatization. But the details in how countries privatized do not seem to have much impact on investment: *Exclusivity* and *SIP* do not have statistically significant effects on investment (Columns (3)-(6)). Competition is also found to increase investment (Columns (7) and (8)), but its effects are statistically insignificant.

To investigate the joint impact of privatization and competition on employment, we include both variables in the regression and report the results in Columns (9)-(11). Notice



that only 38 countries have available data on both *Privatization* and *CompFirm*. We find that the effect of privatization on investment continues to be positive and statistically significant, while the effect of competition is positive and statistically insignificant. Interestingly, estimates of the coefficient on the interaction variable between *Privatization* and *CompFirm* are large and statistically significant. This finding suggests that there is a positive complementarity between privatization and competition in facilitating investment.

**Real Output.** A main policy concern about telecommunications privatization is the extent to which privatized incumbents, facing less government intervention, would choose to exercise their market power. We have seen that privatized firms generally reduced employment substantially. Did they also restrict output? The univariate analysis in Table 3 suggests that they did on average. But the univariate analysis may be affected by sample selection and omitted variables biases. It also cannot address the role that competition played in restructuring the communications sector around the world. To obtain more robust estimates on the effects of both privatization and competition, we run fixed-effects regression on equation (1) under various specifications with  $\ln(Q)$  as the dependent variable. We find again that the estimated effects are qualitatively similar whether or not we include control variables in the regression. To conserve space, we report in Table 6 only the estimates based on specifications that do not include the control variables.

Contrary to the pre- and post-privatization analysis in Table 3, estimates in Table 6 show that privatization appears to have a positive impact on real output. A move from public ownership to partial or full private ownership is associated with an increase in log output by 0.125 (with a t-stat of 1.58), which translates to an increase in output by 13.3% (Column (1)). An incremental increase in non-state ownership share appears to have a statistically insignificant effect on real output (Column (2)). However, since the specifications in Columns (1) and (2) omit other details of the privatization as well as competition, the estimates there are unlikely to be robust. Indeed, when we include the exclusivity dummy variable in the regressions as reported in Columns (3) and (4), we find that the positive marginal effect of privatization (but not the incremental increase in non-state ownership share) is large and statistically significant. A move from public ownership to full or partial private ownership is associated with an increase in log output of 0.778 or

an increase in output by 118%. As expected, granting privatized incumbents exclusive or monopoly access to certain market segments reduces the gain in log output by 0.52. But it is worth noting that privatization even with exclusivity provisions is expected to raise log output by 0.255 (i.e., 0.778-0.523). Whether or not the privatization is done through public issuance of shares (SIP) appears to have a positive but statistically insignificant effect on output, as seen in Columns (5) and (6),

The finding that *Exclusivity* reduces the gains in output from privatization suggests that privatized firms often took advantage of their market power which was protected by the government to extract monopoly rents. Without the market protection afforded by the government, privatized incumbents may have to face market competition from both existing providers and potential new entrants and therefore may choose to increase output. The competitive pressure would be even stronger if the privatizing government actively promoted competition in the sector.

The regression results in Columns (7) and (8) confirm the output enhancing role of competition. An increase in the competition index, *CompFirm*, by one standard deviation is associated with an increase in log output by nearly 0.256 (i.e., 0.217\*1.18). When we enter the numbers of fixed and mobile phone operators separately in the regression (Column (8)), we see that both variables show large positive effect on output.

We also find strong evidence of the complementarity between privatization and competition. In Column (9) we see that the effects on output of both *Privatization* and *CompFirm* are positive, but only the effect of *CompFirm* is statistically significant. In Columns (10) and (11), we find that estimates of the coefficient on the interaction variable, *Privatization\*CompFirm*, are positive and statistically significant. Once we introduce the interaction variable in the regression, estimates of the coefficients on *Privatization* and *CompFirm* as stand-alone variables, while still positive, are no longer statistically significant. The interaction variable becomes the most important explanatory variable in Columns (10) and (11). Our finding of output complementarity between privatization and competition supports the assertion discussed in Section 2 that privatization works best where there is competition.

***Fixed and Mobile Phone Densities.*** Tables 7 and 8 report the estimates of equation (1) with *FixedDensity* and *MobileDensity* in logarithm as the dependent variables. As before, we find qualitatively similar results with or without the additional controls, so we shall discuss only the estimates based on the simpler specification. Focus first on the impact of privatization. Estimates in Columns (1) and (2) in both tables clearly show that both the move to private ownership and the increase non-state ownership shares are positively associated with the expansion of service coverage in fixed line telephony as well as mobile telephony. How a country privatized its telecommunications sector matters a great deal here. Columns (3) and (4) show that exclusivity granted to incumbents has markedly negative impact on both fixed line and mobile phone densities, consistent with output restricting behavior of incumbents exercising market power. Columns (5) and (6) in both Tables 7 and 8 show that share issue privatization is associated with a marked expansion of mobile phone density, but a much weaker response in fixed line phone density.

Turn next to the impact of competition and joint impact of privatization and competition. Estimates in Columns (7) and (8) show that competition alone has limited effects on either fixed line phone density or mobile phone density. After controlling for privatization, competition has a positive impact on mobile density (Column (9), Table 7), but no detectable effects on fixed line density. Inspection of Columns (10) and (11) shows that estimates of the joint effects of privatization and competition—the coefficient on the interaction variable *Privatization\*CompFirm*—are positive and statistically significant. This finding further confirms the complementarity between competition and privatization.

### **4.3. Productivity**

So far we have examined how liberalization reforms affected employment, output, and tele-densities. Another important dimension is how they affected productivity. To the extent that privatization and competition improves technical and allocative efficiencies in the telecommunications sector, they should raise productivity. Below we divide our analysis into two parts. We first estimate the conditional effects of both privatization and competition on labor productivity. We then propose a method for measuring total factor productivity, and estimate how it is affected by privatization and competition.

**Labor productivity.** Using labor productivity measured by real output per employee as the dependent variable, we estimate equation (1) and report the results in Table 9.<sup>15</sup> There we find in Column (1) that full or partial privatization as captured by the privatization dummy increases log labor productivity by a statistically significant 0.196. An incremental increase in non-state equity participation also has a large positive effect on labor productivity as seen in Column (2). But the estimated effect is not statistically significant due perhaps to a sharp reduction in sample size--data on non-state ownership shares are available from only about 40 countries. From Column (3), we see that granting exclusivity to incumbents leads to a marked reduction in labor productivity. Consistent with findings in Tables 4 and 6, this result suggests that, on the margin, the incumbents protected by exclusivity provisions restricted output more than they reduced employment. Countries that privatized without exclusivity provisions would see an increase in log labor productivity on the margin by 0.78, while countries that granted exclusivity to privatized incumbents would only see an increase of 0.33. But when *Exclusivity* is paired with *Non-state share* as in Column (4), the precision of the estimates drops sharply as the sample size is reduced. Columns (5) and (6) show that share issue privatization has positive but statistically insignificant effect on labor productivity.

The effects of competition, and especially competition in the mobile phone segment, are positive and statistically significant. When *CompFirm* is paired with *Privatization* in the regression, the estimates reported in Column (9) show that both competition and privatization have positive effects on labor productivity, but only the effect of competition is statistically significant.

In Columns (10) and (11), we find once again strong evidence of the complementarity between privatization and competition. It is interesting to note that once we introduce the interaction variable in the regression, estimates of the coefficients on *Privatization* and *CompFirm* as stand-alone variables, while still positive, are no longer statistically significant. The interaction variable becomes the dominant explanatory variable.

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<sup>15</sup> We have also run the regressions by including the control variables listed in Table 2. The results, which we omit here, are qualitatively similar to those in Table 8.

**Total factor productivity (TFP).** We show the impact of privatization and competition on TFP by estimating a production function which includes reform variables as explanatory variables. For country  $i$ , the value-added generated by the telecommunications sector in year  $t$ ,  $V_{it}$ , can be expressed in the following translog specification:

$$\ln V_{it} = \mathbf{r}_1 \ln L_{it} + \mathbf{r}_2 \ln K_{it} + \mathbf{r}_{11} (\ln L_{it})^2 + \mathbf{r}_{12} \ln L_{it} \ln K_{it} + \mathbf{r}_{22} (\ln K_{it})^2 + \mathbf{g}' R_{it} + \mathbf{a}t + \mathbf{f}_i + \mathbf{e}_{it}, \quad (2)$$

where  $L_{it}$  and  $K_{it}$  are labor and capital employed,  $R_{it}$  is a vector of reform variables,  $\mathbf{f}_i$  is the country-specific effect, and  $\mathbf{e}_{it}$  is the error term. Total factor productivity defined by the Solow residual is then,

$$\text{TFP}_{it} = \mathbf{g}' R_{it} + \mathbf{a}t + \mathbf{f}_i + \mathbf{e}_{it}. \quad (3)$$

where the vector of coefficients  $\mathbf{g}$  measures the marginal impact of reforms on TFP.

As it stands, equation (2) is not directly estimable because data on  $V_{it}$  and  $K_{it}$  are unavailable. But this problem isn't insurmountable. In Appendix, we discuss the procedure that we use to construct  $K_{it}$  using data on capital expenditure and other available variables. Since data on the usage of intermediate inputs are not available to construct  $V_{it}$ , we take an alternative route. Below we propose a plausible empirical model for  $V_{it}$  that relates it to observed variables. In doing so, we impose additional restrictions on the regression model given in equation (2).

Since the usage of intermediate inputs is determined by the prevailing technology, the intensity of primary inputs used in production and the scale of production, we hypothesize that the relationship between gross output, value added and observable inputs can be expressed in the following flexible specification:

$$\ln(Q_{it}/V_{it}) = \mathbf{r}_1^0 \ln L_{it} + \mathbf{r}_2^0 \ln K_{it} + \mathbf{r}_{11}^0 (\ln L_{it})^2 + \mathbf{r}_{12}^0 \ln L_{it} \ln K_{it} + \mathbf{r}_{22}^0 (\ln K_{it})^2 + \mathbf{a}^0 t + \mathbf{f}_i^0 + \mathbf{e}_{it}^0 \quad (4)$$

where  $\mathbf{e}_{it}^0$  is assumed uncorrelated with explanatory variables in (2). Combining equations (2) and (4) we get,

$$\ln(Q_{it}) = \mathbf{r}_1^* \ln L_{it} + \mathbf{r}_2^* \ln K_{it} + \mathbf{r}_{11}^* (\ln L_{it})^2 + \mathbf{r}_{12}^* \ln L_{it} \ln K_{it} + \mathbf{r}_{22}^* (\ln K_{it})^2 + \mathbf{g}' R_{it} + \mathbf{a}^* t + \mathbf{f}_i^* + \mathbf{e}_{it}^* \quad (5)$$

where coefficients and variables superscripted with an asterisk are simply the sum of their corresponding counterparts in (2) and (4).

With both the dependent and explanatory variables available, equation (5) is estimable. But it is worth noting that because we impose an additional restriction in the model, our estimation of the coefficients of the translog production function and most of the components of the Solow residual in equation (5) will be biased. As a result, the estimation of TFP based on equation (5) will be biased. But the added restriction did not introduce biases on  $g$ , the marginal effects of the reforms on TFP. This is fortunate for  $g$  is what we want to estimate.

Estimates of the equation (5) under various specifications are reported in Table 10. Since the coefficients in the translog production function and the time trend are likely biased as discussed above, our discussion below focuses on estimates of  $g$ .

Consider first the impact of privatization on TFP. Column (1) shows that full or partial privatization increases TFP—or log output after controlling for labor and capital in a flexible translog specification—by 7.2 percentage points. An incremental increase in non-state ownership also has a large effect on TFP as seen in Column (2). An increase in non-state ownership by 10 percentage points would raise TFP on average by 1.5 percentage points. But the effects are not as precisely estimated as to be statistically significant by conventional measures. As we have seen earlier, Column (3) shows that giving privatized incumbents exclusive access to certain market segments has a large deleterious effect on TFP. Countries that privatized with exclusivity provisions underperform those that privatized without exclusivity provisions by a whopping 43.9 percentage points in total factor productivity. But the downside of exclusivity provisions does not completely negate the benefits of privatization. Column (3) shows that privatization even with exclusivity provisions boosts TFP by about 10 percentage points, so it is still better than the status quo—state ownership. When *Exclusivity* is paired with *Non-state share* as in Column (4), the precision of the estimates drops sharply as the sample size is reduced. Estimates in Columns (5) and (6) show that privatization with or without public share offerings does not appear to be significantly different.

Consistent with the finding that exclusivity reduces TFP, the increase in competition as measured by *CompFirm* in Column (7) raises TFP. An increase in *CompFirm* by one standard deviation will increase TFP by 21 percentage points ( $0.18 \times 1.18$ ). Competition in both the fixed-line and mobile telephone markets has positive effects on TFP, though only the effects of mobile competition are statistically significant (see Column (8)). When *CompFirm* and *Privatization* are jointly included in the regression as in Column (9), both have positive effects on TFP, but the effect of competition is markedly larger and is also statistically significant. Competition therefore appears to have a larger impact on TFP than privatization.

In Columns (10) and (11) we include not only *Privatization* and *CompFirm* but also the interaction term of the two variables. Estimates of the coefficients on the interaction term are positive and statistically significant in Column (11). This finding offers evidence of complementarity between privatization and competition.

#### **4.4. Privatization or competition?**

With the association between reforms and improved performance firmly established, we now turn to the task of evaluating the contribution of each of the components of the reforms. Our analyses earlier make it apparent that privatization with exclusivity provisions is less beneficial than one without, while privatizations with and without public share offerings have about the same positive impact on productivity. In what follows, we compare the relative contributions made by privatization, competition, and their interaction during the period between 1990 and 1998 for which we have data.

We list in the first row of Table 11 the sample average of the changes between 1990 and 1998 in each of the dependent variables that we have analyzed. To evaluate the degree to which privatization contributed to the observed changes in employment, we multiply the estimate of the coefficient on *Privatization* in Column (10) of Table 4 by the sample average of the changes of *Privatization* between 1990 and 1998. We repeat this procedure for each of the seven dependent variables and for each of the three reform

variables—*Privatization*, *CompFirm*, and *Privatization\*CompFirm*. The results, expressed as a proportion of the changes in each dependent variable, are given in Table 11.

Log employment on average dropped 0.083 between 1990 and 1998. Privatization was responsible for 32.5% of the changes, and competition –31.8% of the changes (i.e., competition contributed to an increase in employment). The interaction of privatization and competition accounts for 5.8% of the change. Log investment per capita on average increased 0.588 between 1990 and 1998. Privatization was responsible for 48.6% of the change, and competition 10.6% of the changes (i.e., competition contributed to an increase in employment). The interaction of privatization and competition accounts for 14.3% of the change. Log real output increased by 0.35 between 1990 and 1998. Privatization, competition, and their interaction term accounted for 17.6, 18.5, and 14.6 percent, respectively. In all, nearly 51% of the output growth was attributable to privatization and competition. Similarly, privatization and competition had a large impact on network expansion in both fixed-line and mobile telephones.

For labor and total factor productivities, both privatization and competition appeared to be powerful forces. Competition, which accounted for 30% of the increase in log real output after controlling for the contribution of labor and capital, made more contribution than privatization in raising total factor productivity. When privatization was implemented together with increased competition, the interaction variable accounted for 16.5% of the increase in log output after controlling for the contributions of factor inputs. In all, 58% of the increases in log output in the telecommunications sector around the world between 1990 and 1998 can be attributable to the joint impact of privatization and competition on the sector's total factor productivity.

## **5. Conclusion**

By analyzing the impact of privatization and competition on a comprehensive set of indicators of performance in the telecommunications sector in up to 160 countries during the past two decades, we have found strong evidence that both privatization and competition improved performance. Consistent with the prediction that privatized firms are less responsive to politicians' desire for excessive employment; we find that privatization



significantly reduced employment in the telecommunications sector. Moreover countries that transferred more ownership shares to private investors often experienced steeper reductions in employment. In contrast, competitive pressure increased employment. Given the opposite effects that privatization and competition had on employment, it is not surprising that telecommunications employment was stagnant over the past two decades even as output in this sector demonstrated robust growth.

Over half of the robust growth in output was also attributable to the improvement in total factor productivity brought about by privatization and competition. Privatization even with exclusivity provisions was associated with output growth, but its effect was much lower than privatization without exclusivity provisions. This is not surprising since exclusivity provisions protected privatized incumbents from competition in certain market segments. Consistent with this finding, competition is found to raise productivity and output significantly. More important, privatization and competition are found to exhibit strong complementarity. Similarly, we find that a significant portion of the rapid expansion in both fixed-line and mobile networks can be attributed to privatization and competition.

The rapid expansion of output produced by roughly the same number of worker meant that labor productivity in the telecommunications sector grew quickly. We find that over 40% of the increase in labor productivity was attributable to privatization and competition. Since part of the improvement in labor productivity should be attributable to the deployment of more capital, we also derived a method to estimate the impact of privatization and competition on total factor productivity. We found that while both privatization and competition are productivity enhancing, competition appeared to be a more potent force. Our empirical results therefore lend support to the arguments made by many authors (Newbery, 1997; Yarrow, 1986; Kay and Thompson, 1986; Vickers and Yarrow, 1998) that optimal policy requires bundling competition policies with privatization.

## Appendix. Capital stock

In this appendix we describe our procedure for constructing  $K_{it}$ . The available data that we use include capital investment in constant prices, obtained by deflating nominal capital expenditure using GDP deflator, the total number of installed fixed-line telephones, and the macroeconomic control variables listed in Table 2.

Given the real investment  $I_{it}$  in each country, the real value of capital stock can be constructed using the following equation,

$$K_{it} = (1-d)K_{i,t-1} + I_{it} \quad (\text{A.1})$$

if we know the initial value of capital stock,  $K_{i0}$ , and the depreciation rate,  $d$ . Our next step is to propose an empirical model for estimating  $K_{i0}$  and  $d$ .

In principle, the size of the capital stock as a measure of telecommunications capacity should be tightly correlated with the total number of installed fixed-line telephones, especially in earlier years when wireless services did not exist or were not widely deployed. We therefore hypothesize that the following empirical relationship holds before 1985:

$$K_{it} = \mathbf{y} F_{it} + \mathbf{j}' X_{it} + \mathbf{x}_i + \mathbf{h}_{it} \quad (\text{A.2})$$

where  $F_{it}$  is the number of fixed-line telephones,  $X_{it}$  is a time-variant macroeconomic variable (the logarithm of GDP per capita in constant price) that capture factors related to the demand side,  $\mathbf{x}_i$  represents country-specific effects, and  $\mathbf{h}_{it}$  represents the approximation error, which we intend to minimize. Combining equations (A.1) and (A.2), we get

$$I_{it} = \mathbf{y}(F_{it} - (1-d)F_{i,t-1}) + \mathbf{j}'(X_{it} - (1-d)X_{i,t-1}) + d\mathbf{x}_i + \mathbf{h}_{it}^* \quad (\text{A.3})$$

for  $t$  in the early part of the sample. Here  $\mathbf{h}_{it}^* = \mathbf{h}_{it} - (1-d)\mathbf{h}_{i,t-1}$  is the error term.

To minimize the sum of squares of  $\mathbf{h}_{it}^*$ , we run fixed-effects regression based on (A.3) using available data between 1977 and 1983. (The regression results are available from the authors upon request.) We then use the estimates of the coefficients and the fixed effects in (A.2) to construct  $K_{i0}$  for each country for the first year with observable information.<sup>16</sup> Based on the imputed  $K_{i0}$  and the estimate of depreciation rate (14.4%), we construct a time series of capital stock in constant prices using equation (A.1).

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<sup>16</sup> Since we have only slightly less than 50 countries with information on reforms, to make sure that we have enough observations to estimate the effects of reforms on TFP, we need to have a sufficient number of observations for capital stock. The bottleneck turned out to be some disjoint missing observations in the investment series. To impute the missing observations in  $I_{it}$ , we allowed it to be a function of current and lagged observations of the number of main lines, given the strong empirical correlation between investment and the growth of network. The regression has an R-squared of 0.43.

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**Table 1. Privatization and competition in the telecommunications sector: data description and sample statistics.** Since exclusivity was granted only to privatized providers, the exclusivity dummy variable is set to zero if the privatization dummy is zero. The *SIP* dummy in a country is one if the country's privatization of the telecommunications sector is identified in Bortolotti et al. (1999) as a *SIP*. By definition, *SIP* is zero if the privatization dummy is zero.

Variable	Description	# countries and (the range of years) with available data	mean (and s.d.) in 1990	mean (and s.d.) in 1998
<i>Privatization</i>	A dummy variable indicating full or partial privatization of the telecommunications operators. (Source: World Bank Telecommunications Department)	166 (1981-98)	0.108 (0.312)	0.418 (0.495)
<i>Non-state share</i>	Average share of non-state ownership for the incumbent operator(s) for a country-year. (Source: computed based on World Bank-Stanford Data Set on Telecommunication)	43 (1990-98)	0.114 (0.303)	0.490 (0.390)
<i>Exclusivity</i>	A dummy variable indicating that privatized incumbents were given a period of exclusive access to certain market segments. (Source: World Bank-Stanford Data Set on Telecommunication)	162 (1981-98)	0.013 (0.113)	0.148 (0.357)
<i>SIP</i> ( <i>Share Issue Privatization</i> )	A dummy variable indicating whether the country privatized its telecommunications operator(s) through share issue privatization. (Source: Bortolotti, Fantini, and Sinniscalco (1999))	167 (1981-98)	0.024 (0.153)	0.151 (0.359)
<i>NFixed</i>	The total number of fixed phone operators. (Source: World Bank-Stanford Data Set on Telecommunication)	43 (1990-98)	1.788 (2.678)	4.209 (8.573)
<i>NMobile</i>	The total number of mobile phone operators. (Source: World Bank-Stanford Data Set on Telecommunication, and ITU)	55 (1990-98)	0.608 (1.201)	2.648 (3.169)
<i>CompFirm</i>	An index indicating the extent of competition in the telecommunications sectors, including both fixed-line and the mobile segments.  Constructed = $0.71 \cdot \ln(1 + NFixed) + 0.71 \cdot \ln(1 + NMobile)$	42 (1990-98)	-0.666 (0.790)	0.424 (1.073)

**Table 2. Variables that measure the outcome of the telecommunications sector reforms listed together with some control variables.** The range of years given in Column 3 refers to the maximum range of years for which data are available in the sample. For each variable, the sample statistics in 1990 and 1998 are computed using a consistent sample that contains observations available in both years to ensure that the sample statistics are comparable between the two years.

	Description	#country (period)	mean (s.d) in 1990	mean (s.d) in 1998
<b><i>Dependent variables:</i></b>				
<i>L</i>	Number of employees.	188 (1981-98)	26524 (342103)	24779 (67185)
<i>Investment per capita</i>	The total investment per capita (in 1998 US dollars)	154 (1981-98)	42.05 (56.09)	48.78 (64.17)
<i>Q</i>	Real output, measured as revenue (in local currency) divided by the cost of a 3-minute call (in local currency), in billions of 3-minute phone calls.	134 (1982-98)	34.89 (96.99)	70.54 (20.11)
<i>FixedDensity</i>	Number of fixed phone lines per 100 inhabitants.	197 (1981-98)	1.99 (1.31)	2.41 (1.30)
<i>MobileDensity</i>	Number of mobile phone lines per 100 inhabitants.	184 (1981-98)	0.17 (0.38)	1.26 (1.25)
<i>Q/L</i>	Labor productivity, in thousands of 3-minute phone calls per employee	188 (1981-98)	610.6 (559.7)	1060.8 (1137.5)
<b><i>Control Variables:</i></b>				
<i>GDP per capita</i>	Real GDP per capita, in 1995 prices.	205 (1981-98)	5801.54 (8996.62)	6489.40 (10210.60)
<i>Population</i>	Population, in million.	191 (1981-98)	27.26 (105.80)	30.60 (117.96)
<i>Urbanization</i>	Urban population as a percentage of total population.	190 (1981-98)	49.77 (23.34)	53.56 (23.07)



**Table 3. Pre- and Post-privatization comparison of the conduct and performance of a subsample of countries that experienced full or partial privatization in their telecommunications sector.** The range of years given in Column 2 refers to the maximum range of years for which data are available in the sample.

Dependent variable:	#country (period)	Pre-privatization mean (s.d.)	Post-privatization mean (s.d.)	Difference (post-pre) (s.e)	test statistics H0: difference=0
$\ln(L)$	68 (1981-98)	9.650 (1.692)	8.961 (2.332)	-0.689 (0.127)	p-value for Ha difference<0: 0.000
$\ln(\textit{investment per capita})$	61 (1981-98)	3.002 (0.078)	3.462 (0.143)	0.459 (0.149)	p-value for Ha difference>0: 0.001
$\ln(Q)$	51 (1981-98)	23.526 (1.834)	23.049 (2.794)	-0.478 (0.225)	p-value for Ha difference<0 0.017
$\ln(1+\textit{FixedDensity})$	68 (1981-98)	2.264 (1.209)	2.460 (1.202)	0.196 (0.073)	p-value for Ha difference>0: 0.000
$\ln(1+\textit{MobileDensity})$	68 (1981-98)	0.193 (0.198)	0.882 (1.057)	0.690 (0.045)	p-value for Ha difference>0: 0.000
$\ln(Q/L)$	51 (1981-98)	13.586 (1.033)	13.937 (1.065)	0.352 (0.099)	p-value for Ha difference>0: 0.000

**Table 4. The impact of privatization and competition on employment estimated using fixed-effects regression.** The dependent variable is the logarithm of employment in the telecommunications sector,  $\ln(L)$ . Time-invariant country heterogeneity is controlled using country fixed effects. In parentheses are t-statistics. \*, \*\*, \*\*\* represent statistical significance at the 10, 5, and 1 percent levels. Estimates of the country fixed effects and the intercept term are omitted.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
<i>Year</i>	0.012 (11.79)***	-0.001 (0.19)	0.013 (12.81)***	-0.001 (0.11)	0.012 (11.96)***	-0.002 (0.41)	-0.018 (3.96)***	-0.013 (2.74)***	-0.014 (2.50)**	-0.014 (2.45)**	-0.014 (2.44)**
<i>Privatization</i>	-0.168 (8.91)***		-0.083 (2.13)**		-0.110 (4.77)***				-0.047 (1.47)	-0.047 (1.46)	-0.017 (0.34)
<i>Non-state share</i>		-0.228 (3.79)***		-0.377 (4.13)***		-0.234 (3.70)***					
<i>Exclusivity</i>			-0.208 (4.52)***	0.124 (2.16)**							-0.047 (0.89)
<i>SIP</i>					-0.146 (4.40)***	0.028 (0.51)					0.017 (0.31)
<i>CompFirm</i>							0.038 (1.82)*		0.030 (1.12)	0.034 (1.23)	0.036 (1.29)
$\ln(1+ N_{fixed})$								0.097 (3.20)***			
$\ln(1+ N_{mobile})$								-0.024 (0.73)			
<i>Privatization*CompFirm</i>										-0.015 (0.56)	-0.020 (0.71)
Observations	2245	317	2003	317	2245	295	328	328	305	305	305
Number of countries	162	45	160	45	162	42	43	43	40	40	40
R-squared	0.07	0.08	0.10	0.09	0.08	0.08	0.05	0.08	0.06	0.07	0.07

**Table 4b. The impact of privatization and competition on employment estimated using fixed-effects regression with control variables.** The dependent variable is  $\ln(L)$ . Time-invariant country heterogeneity is controlled using country fixed effects. In parentheses are t-statistics. \*, \*\*, \*\*\* represent statistical significance at the 10, 5, and 1 percent levels. Estimates of the country fixed effects and the intercept term are omitted.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Year	-0.009 (4.42)***	-0.019 (2.18)**	-0.007 (3.74)***	-0.022 (2.50)**	-0.008 (4.05)***	-0.022 (2.25)**	-0.038 (4.68)***	-0.034 (4.10)***	-0.036 (3.73)***	-0.036 (3.72)***	-0.036 (3.70)***
$\ln(\text{Population})$	0.836 (9.96)***	-0.127 (0.35)	0.697 (8.28)***	-0.044 (0.12)	0.800 (9.48)***	-0.150 (0.37)	0.167 (0.50)	0.220 (0.66)	0.038 (0.10)	0.037 (0.10)	0.078 (0.21)
Urbanization	0.007 (3.49)***	0.041 (3.55)***	0.010 (5.10)***	0.044 (3.80)***	0.007 (3.51)***	0.046 (3.74)***	0.034 (3.19)***	0.033 (3.05)***	0.040 (3.49)***	0.040 (3.49)***	0.039 (3.37)***
$\ln(\text{GDP per capita})$	0.159 (4.57)***	-0.105 (1.13)	0.152 (4.45)***	-0.081 (0.87)	0.169 (4.86)***	-0.132 (1.29)	-0.185 (2.04)**	-0.169 (1.87)*	-0.178 (1.80)*	-0.171 (1.69)*	-0.180 (1.77)*
Privatization	-0.138 (7.42)***		-0.119 (3.11)***		-0.098 (4.39)***				-0.054 (1.65)*	-0.054 (1.65)	-0.041 (0.80)
Non-state share		-0.248 (4.10)***		-0.424 (4.66)***		-0.256 (4.08)***					
Exclusivity			-0.152 (3.36)***	0.146 (2.57)**							-0.028 (0.53)
SIP					-0.106 (3.24)***	0.020 (0.35)					0.034 (0.62)
CompFirm							0.044 (2.15)**		0.044 (1.65)	0.046 (1.68)*	0.046 (1.67)*
$\ln(1+N_{\text{fixed}})$								0.096 (3.25)***			
$\ln(1+N_{\text{mobile}})$								-0.012 (0.36)			
Privatization*CompFirm										-0.009 (0.32)	-0.013 (0.46)
Observations	2232	317	1990	317	2232	295	328	328	305	305	305
Number of countries	160	45	158	45	160	42	43	43	40	40	40
R-squared	0.13	0.12	0.17	0.15	0.14	0.14	0.11	0.13	0.12	0.12	0.13

**Table 5. The impact of privatization and competition on investment per capita using fixed-effects regression.** The dependent variable is the logarithm of investment per capita in the telecommunications sector. Time-invariant country heterogeneity is controlled using country fixed effects. In parentheses are t-statistics. \*, \*\*, \*\*\* represent statistical significance at the 10, 5, and 1 percent levels. Estimates of the country fixed effects and the intercept term are omitted.

	(1)	(2)	(5)	(6)	(7)	(8)	(3)	(4)	(9)	(10)	(11)
<i>Year</i>	0.048 (9.42)***	0.047 (1.68)*	0.050 (9.61)***	0.048 (1.73)*	0.048 (9.44)***	0.045 (1.45)	0.073 (2.84)***	0.072 (2.71)***	0.014 (0.41)	0.015 (0.46)	0.016 (0.49)
<i>Privatization</i>	0.233 (2.52)**		0.608 (2.97)***		0.288 (2.39)**				0.654 (3.48)***	0.678 (3.62)***	0.390 (1.16)
<i>Non-state share</i>		1.195 (3.31)***		0.728 (1.31)		1.147 (2.97)***					
<i>Exclusivity</i>			-0.043 (0.17)	0.394 (1.11)							0.482 (1.49)
<i>SIP</i>					-0.115 (0.71)	0.244 (0.77)					-0.199 (0.62)
<i>CompFirm</i>							0.121 (1.08)		0.220 (1.46)	0.083 (0.49)	0.063 (0.37)
<i>ln(1+ Nfixed)</i>								0.107 (0.65)			
<i>ln(1+ Nmobile)</i>								0.132 (0.75)			
<i>Privatization*CompFirm</i>										0.303 (1.67)*	0.345 (1.86)*
Observations	1802	267	1609	267	1802	245	278	278	255	255	255
Number of countries	152	42	146	42	152	39	41	41	38	38	38
R-squared	0.08	0.12	0.10	0.12	0.08	0.12	0.08	0.08	0.13	0.14	0.16

**Table 6. The impact of privatization and competition on output estimated using fixed-effects regression.** The dependent variable is the logarithm of real output in the telecommunications sector,  $\ln(Q)$ . Time-invariant country heterogeneity is controlled using country fixed effects. In parentheses are t-statistics. \*, \*\*, \*\*\* represent statistical significance at the 10, 5, and 1 percent levels. Estimates of the country fixed effects and the intercept term are omitted.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
year	0.084	0.083	0.075	0.083	0.084	0.071	0.048	0.049	0.035	0.038	0.038
	(11.98)***	(4.97)***	(9.40)***	(4.96)***	(11.93)***	(3.98)***	(2.54)**	(2.55)**	(1.62)	(1.74)*	(1.74)*
<i>Privatization</i>	0.125		0.778		0.047				0.131	0.142	0.103
	(1.58)		(4.01)***		(0.46)				(1.20)	(1.31)	(0.55)
<i>Non-state share</i>		0.158		0.101		0.144					
		(0.83)		(0.35)		(0.74)					
<i>Exclusivity</i>			-0.523	0.050							0.039
			(2.35)**	(0.26)							(0.21)
<i>SIP</i>					0.162	0.193					0.037
					(1.19)	(1.19)					(0.21)
<i>CompFirm</i>							0.217		0.202	0.089	0.088
							(2.69)***		(2.24)**	(0.84)	(0.82)
$\ln(1+ N_{fixed})$								0.239			
								(1.64)			
$\ln(1+ N_{mobile})$								0.208			
								(1.90)*			
<i>Privatization*CompFirm</i>										0.236	0.231
										(1.98)**	(1.80)*
Observations	987	216	845	216	987	208	221	221	214	214	214
Number of countries	141	39	131	39	141	38	38	38	37	37	37
R-squared	0.20	0.21	0.17	0.21	0.20	0.19	0.21	0.21	0.19	0.21	0.21

**Table 7. The impact of privatization and competition on fixed phone density estimated using fixed-effects regression.** The dependent variable is the logarithm of the number of fixed line telephones per 100 inhabitants. Time-invariant country heterogeneity is controlled using country fixed effects. In parentheses are t-statistics. \*, \*\*, \*\*\* represent statistical significance at the 10, 5, and 1 percent levels. Estimates of the country fixed effects and the intercept term are omitted.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Year	0.039 (54.98)***	0.066 (16.87)***	0.039 (54.90)***	0.065 (17.06)***	0.039 (54.98)***	0.063 (14.95)***	0.075 (20.50)***	0.078 (20.20)***	0.073 (15.91)***	0.072 (15.89)***	0.072 (15.87)***
<i>Privatization</i>	0.086 (6.06)***		0.365 (11.03)***		0.088 (5.21)***				0.046 (1.76)*	0.046 (1.83)*	0.053 (1.28)
<i>Non-state share</i>		0.188 (3.63)***		0.389 (4.97)***		0.182 (3.39)***					
<i>Exclusivity</i>			-0.240 (6.19)***	-0.164 (3.38)***							-0.020 (0.48)
<i>SIP</i>					-0.007 (0.27)	0.081 (1.76)*					0.031 (0.71)
<i>CompFirm</i>							0.004 (0.22)		-0.007 (0.32)	-0.027 (1.23)	-0.027 (1.21)
<i>ln(1+ Nfixed)</i>								0.047 (1.92)*			
<i>ln(1+ Nmobile)</i>								-0.040 (1.53)			
<i>Privatization*CompFirm</i>										0.078 (3.61)***	0.073 (3.32)***
Observations	2832	331	2570	331	2832	307	338	338	315	315	315
Number of countries	162	45	160	45	162	42	43	43	40	40	40
R-squared	0.61	0.66	0.62	0.67	0.61	0.65	0.71	0.72	0.71	0.72	0.72

**Table 8. The impact of privatization and competition on mobile phone density estimated using fixed-effects regression.** The dependent variable is the logarithm of the number of mobile telephones per 100 inhabitants. Time-invariant country heterogeneity is controlled using country fixed effects. In parentheses are t-statistics. \*, \*\*, \*\*\* represent statistical significance at the 10, 5, and 1 percent levels. Estimates of the country fixed effects and the intercept term are omitted.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Year	0.046 (25.46)***	0.141 (13.78)***	0.041 (26.14)***	0.141 (13.77)***	0.045 (27.07)***	0.133 (12.58)***	0.143 (13.59)***	0.147 (13.15)***	0.124 (9.55)***	0.118 (9.44)***	0.119 (9.65)***
<i>Privatization</i>	0.501 (13.96)***		0.531 (7.16)***		0.070 (1.74)*				0.071 (0.98)	0.081 (1.17)	-0.039 (0.34)
<i>Non-state share</i>		0.241 (1.76)*		0.440 (2.10)**		0.152 (1.13)					
<i>Exclusivity</i>			-0.191 (2.21)**	-0.163 (1.25)							0.035 (0.31)
<i>SIP</i>					1.195 (19.37)***	0.568 (4.87)***					0.373 (3.15)***
<i>CompFirm</i>							0.071 (1.46)		0.187 (3.06)***	0.111 (1.85)*	0.092 (1.53)
$\ln(1+ N_{fixed})$								0.127 (1.80)*			
$\ln(1+ N_{mobile})$								0.013 (0.18)			
<i>Privatization*Comp</i>										0.300 (5.14)***	0.273 (4.61)***
Observations	2807	332	2548	332	2807	309	338	338	316	316	315
Number of countries	160	45	157	45	160	42	43	43	40	40	40
R-squared	0.35	0.54	0.30	0.54	0.43	0.58	0.55	0.56	0.57	0.60	0.62

**Table 9. The impact of privatization and competition on labor productivity estimated using fixed-effects regression.** The dependent variable is the logarithm of labor productivity,  $\ln(Q/L)$ . Time-invariant country heterogeneity is controlled using country fixed effects. In parentheses are t-statistics. \*, \*\*, \*\*\* represent statistical significance at the 10, 5, and 1 percent levels. Estimates of the country fixed effects and the intercept term are omitted.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Year	0.081 (11.34)***	0.083 (4.63)***	0.070 (8.55)***	0.083 (4.61)***	0.081 (11.30)***	0.073 (3.80)***	0.056 (2.81)***	0.054 (2.65)***	0.042 (1.79)*	0.045 (1.93)*	0.045 (1.93)*
<i>Privatization</i>	0.196 (2.43)**		0.781 (3.95)***		0.144 (1.38)				0.139 (1.19)	0.152 (1.31)	0.117 (0.59)
<i>Non-state share</i>		0.263 (1.28)		0.319 (1.02)		0.250 (1.18)					
<i>Exclusivity</i>			-0.451 (1.99)**	-0.050 (0.24)							0.066 (0.33)
<i>SIP</i>					0.108 (0.77)	0.164 (0.93)					-0.036 (0.18)
<i>CompFirm</i>							0.211 (2.45)**		0.212 (2.19)**	0.078 (0.69)	0.073 (0.64)
$\ln(1+ N_{fixed})$								0.119 (0.76)			
$\ln(1+ N_{mobile})$								0.265 (2.25)**			
<i>Privatization*CompFirm</i>										0.280 (2.19)**	0.293 (2.14)**
Observations	987	216	845	216	987	208	221	221	214	214	214
Number of countries	141	39	131	39	141	38	38	38	37	37	37
R-squared	0.19	0.21	0.16	0.21	0.19	0.19	0.21	0.21	0.20	0.22	0.22



**Table 10. The impact of privatization and competition on total factor productivity estimated using fixed-effects regression.** The dependent variable is the logarithm of real output. The capital stock variable is constructed using available investment data from ITU; see the Appendix for more details. Time-invariant country heterogeneity is controlled using country fixed effects. In parentheses are t-statistics. \*, \*\*, \*\*\* represent statistical significance at the 10, 5, and 1 percent levels. Estimates of the country fixed effects and the intercept term are omitted.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
<i>Year</i>	0.069 (8.27)***	0.082 (3.41)***	0.063 (6.37)***	0.082 (3.40)***	0.068 (8.20)***	0.085 (3.46)***	0.043 (1.64)	0.041 (1.53)	0.033 (1.21)	0.043 (1.54)	0.044 (1.55)
<i>ln(L)</i>	5.103 (1.31)	-11.454 (1.65)	2.181 (0.48)	-13.013 (1.84)*	6.378 (1.60)	-15.549 (2.09)**	-6.198 (1.01)	-6.094 (0.99)	-10.590 (1.54)	-9.183 (1.33)	-10.013 (1.41)
<i>ln(L)*ln(L)</i>	-2.838 (0.91)	-1.608 (0.48)	-4.385 (1.16)	-1.251 (0.37)	-3.134 (1.00)	-5.820 (1.28)	-1.736 (0.51)	-1.789 (0.52)	-4.973 (1.07)	-4.591 (0.99)	-5.394 (1.13)
<i>ln(K)</i>	0.080 (1.18)	-0.084 (0.78)	0.075 (0.94)	-0.066 (0.60)	0.071 (1.05)	-0.151 (1.29)	-0.125 (1.22)	-0.124 (1.21)	-0.172 (1.46)	-0.172 (1.47)	-0.172 (1.46)
<i>ln(K)*ln(K)</i>	-0.120 (1.08)	0.223 (1.19)	-0.074 (0.58)	0.265 (1.39)	-0.152 (1.35)	0.258 (1.33)	0.100 (0.60)	0.097 (0.58)	0.155 (0.82)	0.126 (0.66)	0.136 (0.71)
<i>ln(L)*ln(K)</i>	0.082 (0.46)	0.136 (0.67)	0.154 (0.72)	0.104 (0.51)	0.102 (0.57)	0.383 (1.43)	0.176 (0.89)	0.178 (0.90)	0.361 (1.32)	0.344 (1.26)	0.381 (1.36)
<i>Privatization</i>	0.072 (0.83)		0.533 (2.49)**		-0.044 (0.38)				0.097 (0.78)	0.092 (0.75)	0.046 (0.24)
<i>Non-state share</i>		0.153 (0.69)		-0.074 (0.25)		0.181 (0.79)					
<i>Exclusivity</i>			-0.439 (1.84)*	0.227 (1.17)							0.111 (0.58)
<i>SIP</i>					0.224 (1.52)	0.061 (0.36)					-0.081 (0.43)
<i>CompFirm</i>							0.185 (2.19)**		0.238 (2.60)**	0.134 (1.20)	0.133 (1.19)
<i>ln(1+Nfixed)</i>								0.146 (0.95)			
<i>ln(1+Nmobile)</i>								0.209 (1.84)*			
<i>Privatization*CompFirm</i>										0.215 (1.63)	0.228 (1.68)*
<i>Observations</i>	874	192	750	192	874	184	200	200	193	193	193
<i>Number of countries</i>	120	34	112	34	120	33	34	34	33	33	33
<i>R-squared</i>	0.22	0.30	0.18	0.30	0.22	0.27	0.27	0.27	0.26	0.27	0.27

**Table 11. Estimates of the contribution of privatization and competition to changes in performance in the telecommunications sector around the world.**

	$\ln(L)$	$\ln(\text{Investment per capita})$	$\ln(Q)$	$\ln(\text{FixedDensity})$	$\ln(\text{MobileDensity})$	$\ln(Q/L)$	$\ln(Q)$ with control for factor inputs using a translog production function
$\Delta y$	-0.083	0.588	0.334	0.502	1.055	0.432	0.334
percentage of $\Delta y$ explained by:							
Privatization	32.5%	48.6%	17.6%	5.3%	4.6%	15.2%	11.7
CompFirm	-31.8%	10.6%	18.5%	-4.5%	8.9%	13.1%	29.9
privatization* CompFirm	5.8%	14.3%	14.6%	5.3%	9.3%	14.0%	16.5