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An Econometric Assessment of Telecommunications Prices and Consumer Surplus in Mexico Using Panel Data

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Abstract *We analyze telecommunications prices in Mexico by using a panel data of countries similar to Mexico to estimate demand models for mobile and fixed-line telecommunications. We find that Mexico's actual mobile and fixed-line prices are below the predicted prices based on similar countries' prices. Mexican consumers are paying lower prices than what one would expect based on comparisons of comparable countries. We calculate that in 2011 Mexican consumers received at least $4 to $5 billion (USD) in consumer surplus from these lower mobile prices and in 2010 they received over $1 billion (USD) in consumer surplus from these lower fixed-line prices. These findings are in contrast to the general perception that concentrated telecommunications markets in Mexico are resulting in high prices and harming consumers.*

Keywords telecommunications demand, econometric demand model, consumer surplus, Mexico

JEL Classification C33 C36 L51 L96

1 INTRODUCTION

The Mexican telecommunications market is generally considered more concentrated than telecommunications markets in other OECD countries. This has led some authors to conclude that consumers in Mexico pay high prices and that there are large losses in consumer surplus.[1] Moreover, regulators in Mexico are contemplating asymmetric regulation of the dominant mobile operator (including regulation of retail mobile prices) due, in part, to the perception of high prices and concentration. In telecommunications, however, high market share is a necessary but not a sufficient condition for a finding of market power and supra-competitive prices. Because of minimum efficient scale of operation relative to total demand, most countries have few facilities-based operators—three to five facilities-based mobile operators and fewer fixed-line operators. Yet competition in telecommunications markets can be robust with more countries moving further away from active sector regulation and relying more on general antitrust/competition policy laws.

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[1] A recent study from the Organization for Economic Cooperation and Development (OECD) published in January 2012 entitled, "Estimation of Loss in Consumer Surplus Resulting from Excessive Pricing of Telecommunication Services in Mexico" concludes that high pricing of Mexico's telecommunications services caused a loss in consumer surplus estimated at $129.2 billion (USD) from 2005 to 2009, or 1.8 percent of Mexico's annual GDP, OECD (2012). We have critiqued the OECD (2012) econometric analysis and price data sources extensively in Hausman and Ros (2012).

In this paper we find that concentration is a poor predictor of performance for the Mexican telecommunications market. We develop econometric demand models that show that mobile and fixed-line prices in Mexico are actually *lower* than one would expect based on comparable countries. In 2011, mobile prices in Mexico were 32 to 60 percent lower than the model's prediction—corresponding to additional consumer surplus of $4 to $5 billion. Similarly, in 2010, fixed-line prices were about 15 percent lower than the model's predictions—corresponding to additional consumer surplus of $1 billion. Our models together show that, based on comparable countries, low mobile and fixed-line pricing in Mexico resulted in at least an additional *$5 to $6 billion* in consumer surplus in 2010 and 2011. These findings suggest that prior to the imposition of regulations (especially mobile retail price regulations) regulators should examine all economic factors that are important determinants of market power including market share, supply elasticity, and demand elasticity.

In Section 2 we present our econometric analysis. We begin with a discussion of the methodology and approach used to select a sample of comparable countries used in the econometric analysis as well as a discussion of the underlying data used in the study and the consumer surplus calculations. Section 2 is divided between analysis for the Mexican mobile sector and the Mexican fixed-line sector. In Section 3 we present our conclusions and regulatory implications.

2 ECONOMETRIC ASSESSMENT OF TELECOMMUNICATIONS PRICES IN MEXICO

2.1 Selection of the Sample of Countries

We select a sample of comparable countries to conduct our analysis based upon income levels. We began our selection of peer countries by ranking countries by GDP per capita. Although we use market exchange rates in the rankings, our sample of peer countries does not change if we used PPP. We selected a sample of countries that were above and below Mexico in a ranking of GDP per capita. Our sample selection criteria were countries with similar levels of GDP per capita as Mexico and availability of our mobile price data. For mobile price data we use Bank of America/Merrill Lynch (BoA/ML). The BoA/ML data are frequently used and represent actual expenditures rather than some other non-market based measures, such as the price for a hypothetical mobile call of a given length. BoA/ML provides mobile price data for approximately 50 countries.

Mexico is an upper middle income country based upon World Bank income group classification. We included 8 upper middle income countries in our sample, which are most of the upper middle income countries in the BoA/ML data.[2] In order to increase the sample size, we selected 8 additional countries and to be conservative the countries selected were high income countries. We did not include any country, however, that had a GDP per capita greater than $30,000. Table 1 lists the economic and telecommunications characteristics of Mexico and the 16 peer countries used in our analysis. It is worth noting that Mexico's GDP per capita is below all selected countries' GDP per capita values except for four countries: Malaysia, South Africa, Colombia and Peru.

[2] The remaining BoA/ML upper middle income countries not selected were dropped because of other data constraints such as not having the sufficient yearly data.

TABLE 1: MEXICO AND PEER COUNTRIES, 2010 ECONOMIC AND TELECOMMUNICATIONS INDICATORS

Country Name	GDP per Capita (Market Exchange Rate - MER)	GDP per Capita (Purchasing Power Parity - PPP)	Population	Mobile Cellular Telephone Subscriptions per 100 Inhabitants	Fixed Telephone Lines per 100 Inhabitants
Mexico	$9,123	$14,498	113,423,047	80.6	17.5
Argentina	$9,124	$16,012	40,412,376	141.8	24.7
Brazil	$10,710	$11,210	194,946,470	104.1	21.6
Chile	$12,431	$15,732	17,113,688	116.0	20.2
Colombia	$6,225	$9,462	46,294,841	96.1	15.5
Czech Republic	$18,245	$25,283	10,492,960	137.2	22.9
Greece	$26,600	$27,805	11,359,346	108.2	45.8
Hungary	$12,852	$20,029	9,983,645	120.3	29.8
Israel	$28,504	$28,546	7,418,400	133.1	44.2
Korea	$20,757	$29,004	48,183,584	105.4	59.2
Malaysia	$8,373	$14,731	28,401,017	119.2	16.1
Peru	$5,401	$9,538	29,076,512	100.1	10.9
Poland	$12,293	$19,783	38,276,660	122.7	20.0
Portugal	$21,505	$25,610	10,675,572	142.3	42.0
Russia	$10,440	$19,840	142,958,164	166.3	31.4
South Africa	$7,275	$10,570	50,132,817	100.5	8.4
Turkey	$10,094	$15,321	72,752,325	84.9	22.3

Note: All variables are 2010 values.
Sources: World Telecomm./ICT Database 2011, The World Bank.

Our sample of peer countries consists of countries whose GDP per capita ranges from a high of $28,504 (Israel) to a low of $5,401 (Peru). Mexico's GDP per capita is on the low side at $9,123. Some of the peer countries are OECD countries such as Chile, the Czech Republic, Greece, Hungary, Israel, Korea, Poland, Portugal, and Turkey. Peer countries in Latin America are Argentina, Brazil, Chile, Colombia, and Peru. Peer countries in Asia are Korea and Malaysia.

2.2 Previous findings

Based upon the panel data we estimate demand models and price and income elasticities. Hausman (1997) found an income elasticity of 0.193 in the top thirty US cellular markets. Garbacz and Thompson (2007) found income elasticity values in a sample of developing countries for residential fixed-line telecommunications services to range between 0.291 and 0.476 and between 0.93 and 1.21 in mobile telecommunications services. Madden, Coble-Neal, and Dalzell (2004), analyzing mobile telephone markets, found an income-elasticity value of 3.47, in a selected sample of high-income countries; and an income-elasticity value of 4.76 in a global sample of countries. A more recent study carried out by Haucap, Heimeshoff, and Karacuka (2011) found an income elasticity value of 0.157 in the Turkish mobile telecommunication market. Furthermore, Kathuria, Uppal, and Mamta (2009) found an income elasticity value in India of 2.45 in the mobile market. Likewise, Lee and Lee (2006) found income elasticity values between 0.626 and 0.655 in Korea in the mobile market. Finally, Waverman, Meschi and Fuss (2005) found a mobile-market income elasticity value of 1.95 in a sample of low and high income countries.

Similarly, this same literature also casts light on own-price elasticity estimates in the telecommunications sector. Hausman's study (1997) found an own-price elasticity of -0.506. Garbacz and Thompson (2007) calculated own-price elasticity values in the residential fixed-line telecommunications services ranging between -0.002 and 0.011 and for mobile telecommunications services ranging between -0.195 to -1.268. Madden, Coble-Neal, and Dalzell (2004) found an own-price elasticity value of -0.53 (sample of high-income countries) and -0.55 (global sample of countries). Haucap, Heimeshoff, and Karacuka (2011) found an own-price elasticity value of -0.277. On the other hand, Kathuria, Uppal, and Mamta (2009) estimated a value of -2.12. Lee and Lee (2006) calculated values between -0.482 and -0.643. Finally, Wavernman, Meschi and Fuss (2005) estimated a value of -1.50.

2.3 Mobile telecommunications prices in Mexico and consumer surplus

We first analyze mobile demand and mobile prices in Mexico. The data span the period from 2004 to 2011, and we use a sample comprising Mexico and sixteen additional countries that each has a per-capita GDP comparable to that of Mexico. Our analysis finds that Mexico's mobile prices are quite low compared with the prices of the other sixteen countries in our sample.

We then estimate econometric models of mobile demand and mobile prices. Our econometric models demonstrate that price and per-capita GDP are important determinants of mobile demand. Although Mexico's mobile penetration is low compared with the other sixteen countries, we do not find high prices to be the cause; indeed, as we explain, Mexico has low prices. Rather, characteristics specific to Mexico (*e.g.,* extent of rural area and makeup, lack of universal service program, *etc*), which are captured by country-specific variables in a fixed effects econometrics specification, explain Mexico's lower-than-expected mobile penetration.

We also estimate price equations. Based on the predictions of our model, we find that Mexico's prices have been lower than one would expect based on prices in comparable countries since 2006 and have decreased more rapidly than mobile prices in comparable countries. We estimate that Mexican consumers have experienced consumer surplus of $4 to $5 billion greater than expected based on comparable countries.

2.3.1 Cross-Country Comparison of Mexico's Mobile Prices

We first compare Mexican mobile prices with the sample of comparable countries, chosen on a GDP per capita basis. We then estimate mobile demand and price equations for our seventeen-country sample using quarterly data for the period from the second quarter of 2004 to the third quarter of 2011. We selected our sample of countries based upon their having per-capita GDPs similar to that of Mexico. Mexico ranks thirteenth among the seventeen countries in terms of GDP per capita. The panel data set has 507 observations because of three missing observations in 2004. The primary variables we use in the model are price, per-capita GDP, and mobile penetration. We used Voice Revenue per Minute (VRPM) as the basis for the econometrics. VPRM is a measure of mean prices actually paid in the market by mobile customers.[3] We note that the US Federal communications Commission (FCC) has used VPRM for at least the last 10 years as a basis for its analysis of mobile competition in the US, rather than the hypothetical prices based on tariff filings, which the OECD (2012) used in its analysis.[4] Table 2 reports the relevant data on the seventeen countries in our sample, including Mexico.

TABLE 2: DATA AVAILABLE FOR SAMPLE COUNTRIES, Q3 2011, RANKED LOW TO HIGH BY VRPM

Country	**Voice Revenue Per Minute (USD)**	**GDP per Capita Market Exchange Rate**	**Total Subscribers (Wireless)**	**Population**	**Penetration Rate (%)**
Turkey	$0.040	$10,947	64,728,000	73,852,520	88
Mexico	$0.041	$10,193	96,516,100	115,122,300	84
Russia	$0.043	$13,553	227,444,856	142,777,500	159
Colombia	$0.052	$7,556	46,610,058	45,910,847	102
Israel	$0.056	$32,616	10,000,000	7,714,280	130
Poland	$0.068	$13,649	49,945,000	38,152,320	131
Peru	$0.073	$6,204	25,634,800	29,713,754	86
Malaysia	$0.076	$10,115	35,109,500	28,460,470	123
Chile	$0.076	$13,771	23,131,500	17,308,710	134
Korea	$0.078	$23,788	52,121,000	48,692,220	107
Hungary	$0.085	$14,617	11,231,779	9,985,421	112
Brazil	$0.085	$12,977	231,314,398	197,106,500	117
Greece	$0.099	$26,263	15,558,218	11,339,550	137
Argentina	$0.110	$11,011	54,442,300	40,853,340	133
Portugal	$0.113	$22,788	17,174,000	10,658,500	161
Czech Republic	$0.125	$21,067	13,700,200	10,525,470	130
South Africa	$0.138	$8,239	57,152,193	50,535,380	113

Notes: Voice revenue per minute and GDP per capita are both presented in U.S. dollars. We converted all voice revenue and GDP figures into U.S. dollars by using contemporaneous exchange rates from Bank of America-Merrill Lynch "Global Wireless Matrix" reports. The U.S. CPI used for conversion is available from the U.S. Bureau of Labor Statistics at http://www.bls.gov/cpi/. We calculated the mobile penetration rate by dividing total wireless subscribers by the total population.

Sources: BANK OF AMERICA-MERRILL LYNCH, GLOBAL WIRELESS MATRIX FOR 4TH QUARTER 2011 (2011); BANK OF AMERICA-MERRILL LYNCH, GLOBAL WIRELESS MATRIX FOR 3RD QUARTER 2011 (2011); BANK OF AMERICA- MERRILL LYNCH, GLOBAL WIRELESS MATRIX FOR 1ST QUARTER 2007 (2007). With the exceptions of Israel, Colombia, and Peru, GDP per capita and population data are from Oxford Economics (via Thomson DataStream). OXFORD ECONOMICS, http://www.oxfordeconomics.com/. For Israel's GDP data, we used the Central Bureau of Statistics of Israel. CENTRAL BUREAU OF STATISTICS, http://www1.cbs.gov.il (Isr.) (to view the website in English, use http://www1.cbs.gov.il/reader/cw_usr_view_Folder?ID=141). I used the OECD for Israel's population data. OECD, http://www.oecd.org. For both Columbia's GDP and population data, we used the *Departamento Administrativo Nacional de Estadistica de Colombia*. DEPARTAMENTO ADMINISTRATIVO NACIONAL DE ESTADISTICA [NAT'L BUREAU OF STATISTICS], http://dane.gov.co (Colom.). We used the *Instituto Nacional de Estadistica e Informatica del Peru* both for Peru's GDP data and for Peru's population data. Instituto Nacional de Estadistica e Informatica [National Institute of Statistics and Informatics], http://www.inei.gob.pe (Peru). Mobile subscriber data are from TeleGeography's total wireless subscribers. TELEGEOGRAPHY, http://www.telegeography.com/.

[3] Specifically, we used voice revenue per minute from Bank of America- Merrill Lynch because those data are frequently used and represent *actual* expenditures rather than some other non-market based measures, such as the price for a hypothetical mobile call of a given length. Although errors in variables (EIV) may exist in the Bank of America – Merrill Lynch data as a measure of price, EIV should not present a significant problem because we always treat the price variable as (jointly) endogenous. *See, e.g.*, Hausman (1977).

[4] The FCC also examines the cellular component of the CPI for determining cellular service price trends, see FCC 15th Annual Mobile Wireless Competition Report.

Although not reflected in the tables above, we also estimated voice revenue per minute using purchasing power parity (PPP) deflated prices. We believe that the PPP-deflated approach is inferior to the exchange rate approach because, with the exception of Korea, all mobile equipment is manufactured outside the countries in the sample and subsequently traded in world markets. The same applies for fixed-line equipment. The cost of the telecommunications equipment will be a major determinant of mobile and fixed-line prices.[5] Regardless, we find similar results using PPP-adjusted prices.

In terms of price (VRPM) Mexico is one of the three countries with the lowest mobile prices (along with Russia and Turkey). The average price per minute is $0.04 in each of those three countries. Notably, Mexico has the *lowest price* of any Latin American nation in the sample. In terms of prices adjusted by PPP (which we consider to be an inferior measure of price), Mexico, Russia, Israel, and Turkey are the four countries with the lowest prices.[6] Mexico also has the lowest PPP-adjusted prices of any Latin American nation in the sample. Our findings directly contradict the OECD (2012) findings that Mexico has high mobile prices. Our results differ from the OECD (2012) results because we use actual prices rather than hypothetical prices and we also use a set of countries comparable to Mexico in GDP per capita, while the OECD (2012) uses a sample of countries all of which have higher (and often much higher) GDP per capital than Mexico.

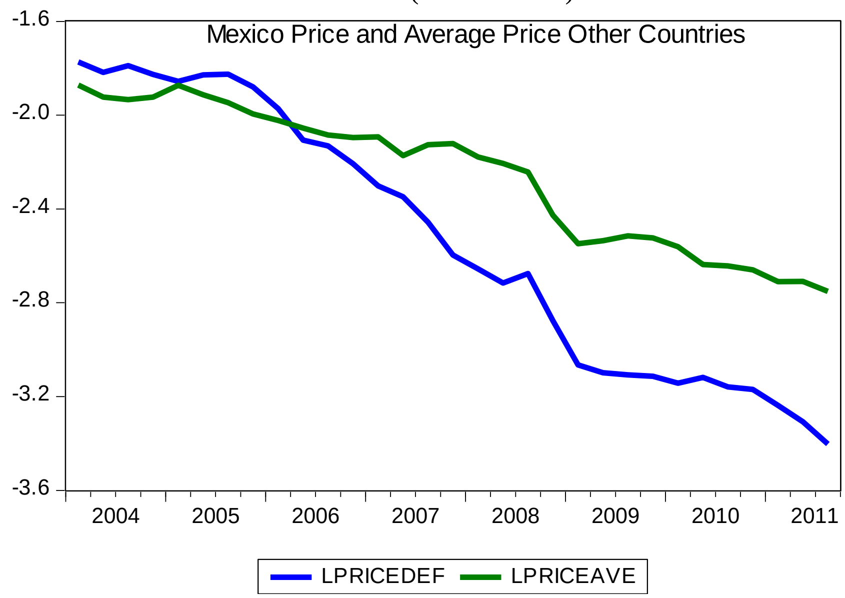
Mexico has the lowest mobile penetration rate in the sample (84 percent), followed closely by Peru (86 percent) and Turkey (88 percent). However, mobile penetration data must be treated with caution because the reported penetration of many countries exceeds 100 percent. This can happen because some individuals may subscribe to more than one company and because pre-paid is the main form of subscription and this can create situations where companies continue to count subscribers as customers for a short period of time when in fact they have switched to an alternative provider. Below, we use an econometric method (fixed effects), which accounts for this problem with reported penetration data.

In Figure 1, we graph the log of Mexico's mobile prices (LPRICEDEF) alongside the average of the log mobile prices of the other sixteen countries (excluding Mexico) (LPRICEAVE). Mexico's log prices were above the average of other countries' log prices only until the second quarter of 2006. Since then, Mexico's mobile prices have been below the average of the other countries' prices. In 2011, Mexico prices were 59.3 percent below the average of the other sixteen counties. Figure 1 shows that prices in Mexico have declined more rapidly than has the average price of the other sixteen countries.

[5] In addition, as discussed in Hausman (2010), "PPPs are basically multi-lateral price indices which inherit the problems of price indices in individual countries, especially in their incorrect treatment of new goods." See also, Deaton (2010) for a discussion of additional critiques of PPP.

[6] Mexico's PPP-adjusted price in 2011 Q3 is $0.0582. The mean PPP-adjusted price is $0.105. Mexico is below the 95% confidence interval for the mean.

FIGURE 1: MEXICO'S LOG PRICES (LPRICEDEF) AND THE AVERAGE LOG PRICES OF OTHER COUNTRIES (LPRICEAVE)



2.3.2 Econometric Estimation of Mexico's Mobile Demand

We first estimate demand equations for mobile services for a seventeen-country sample to determine the price-elasticity of demand and the GDP-per-capita elasticity of demand for mobile service in Mexico. In these demand equations, mobile penetration is the left-hand side, dependent variable. (That is, we are measuring how mobile penetration changes when other variables, such as income and price, change.)

Because countries can have penetrations equal to and exceeding 100 percent (including babies in the population!), fixed-effects estimation, which allows for a separate intercept for each country, is the preferred model specification approach. The Hausman specification test is the standard test to determine whether fixed effects or random effects is the preferred model specification.[7] For the mobile penetration equation, we find the Hausman test statistic to equal 11.4 with 2 degrees of freedom, so the probability that the random-effects estimator is appropriate is 0.0033. This low probability rejects the use of random effects. Consequently, for our demand estimation specification, we use a fixed-effects specification. If fixed effects are not used, the model will produce biased and inconsistent estimates.[8]

To estimate the fixed-effects specification, we use a first-difference generalized method-of-moments (GMM) estimator.[9] Using GMM with first differences eliminates the fixed effects and yields a consistent estimation method. For the right-hand side, explanatory variables, we take GDP per capita to be an exogenous variable. We expect

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[7] Hausman (1978). *See also* Kennedy (2003), Baltagi (2011) and Greene (2003). High values for the test statistic will indicate that fixed-effects modeling is superior to random-effects modeling.

[8] *See* Hausman & Taylor (1981). *See also* HSIAO (2003) AND BALTAGI (2008).

[9] *See, e.g.*, KENNEDY (2003) pp. 151-52.

mobile price to be jointly endogenous, so we will need an appropriate instrument.[10] As an instrument for price, we use the approach developed by Hausman and William Taylor, which Hausman has used in a number of academic papers and are now often known as "Hausman instruments."[11] The idea is that (variable) cost may be the best instrument for price. However, econometricians often do not have access to cost information, as in the current situation. For the price in a given market, prices in other markets are effective instruments. Prices across countries should be correlated due to common cost variables, and these prices should be independent of the stochastic error terms as long as there are no common demand shocks in the data. For each country, we use the mean of the price for the other 16 countries as an instrument.[12] All of the countries will have similar cost behavior over time since the mobile equipment industry is highly competitive and the countries all use a common technology. Table 3 shows the estimated coefficients in the demand equation.[13]

TABLE 3: ESTIMATION OF FIXED-EFFECTS DEMAND EQUATION OVER 17 COUNTRIES

Dependent Variable: DLPEN
Method: Panel Generalized Method of Moments

Sample (adjusted): 2004Q2 2011Q3
Periods included: 30
Cross-sections included: 17
Total panel (unbalanced) observations: 507
White period instrument weighting matrix
Period SUR (PCSE) standard errors & covariance (d.f. corrected)
Instrument specification: C DLGDPDEF DLPRICEIV1

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLPRICEDEF	-0.524090	0.069200	-7.573586	0.0000
DLGDPDEF	0.425284	0.050499	8.421615	0.0000

Mean dependent var	0.033212
S.D. dependent var	0.043070
S.E. of regression	0.060355

[10] A Hausman specification test for the joint endogeneity of price rejects the hypothesis that price is exogenous. The test statistic is 24.8, which is distributed as chi square with 1 degree of freedom. The *p*-value is 0.00000065. Endogeneity can be a problem because, if unobserved variables jointly affect both the dependent and independent variables, then the coefficient estimates for the independent variables may be biased. An instrument is used to adjust for this problem. An effective instrument will be correlated with the independent variable (in this case, price) but not correlated with the unobserved variables, which are captured by the stochastic error terms.

[11] Hausman & Taylor (1981) For applications of this approach, see Hausman et. al (1994); Hausman (1997) and Hausman & Leonard (2002). , *The Competitive Effects of a New Product Introduction: A Case Study*, 50 J. INDUS. ECON. 237 (2002). For another application of the approach, see Nevo (2001).

[12] This approach passes the "weak instrument" tests. Also, the estimate of the price variable coefficient in the demand equation is very precise.

[13] We use the econometric software Eviews for the estimation.

The left-hand side, dependent variable is the change in the log of mobile penetration. The coefficient on the change in the log of price is the price elasticity of demand, and it is estimated to be –0.524 and statistically significant (with a *t*-statistic = 7.57). This estimate is similar to results of some other studies; however, studies have found results somewhat lower and much higher. We also find a positive, significant effect of GDP per capita on changes in mobile penetration, with an estimated elasticity of 0.425 (and a *t*-statistic = 8.42).[14] We find similar results if we use PPP-deflated variables instead of market exchange rates.[15]

To test the use of the "Hausman instrument" for price, we re-estimate the demand specification using a time trend as the instrument instead. Time should provide a reliable instrument for prices because prices are trending downward over time. Table 4 presents the results. Using a time trend as the instrumental variable for price produces a very similar price elasticity of demand estimate of –0.593, although it is not as precisely estimated as in Table 3 (*t*-statistic = –5.97). The GDP-per-capita elasticity is also very similar to our initial estimation in Table 3, estimated at 0.445.[16]

TABLE 4: ESTIMATION OF FIXED-EFFECTS DEMAND EQUATION
USING A TIME TREND AS AN ALTERNATIVE INSTRUMENT

Dependent Variable: DLPEN
Method: Panel Generalized Method of Moments

Sample (adjusted): 2004Q2 2011Q3
Periods included: 30
Cross-sections included: 17
Total panel (unbalanced) observations: 507
White period instrument weighting matrix
Period SUR (PCSE) standard errors & covariance (d.f. corrected)
Instrument specification: C DLGDPDEF TIME

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLPRICEDEF	-0.593077	0.099297	-5.972754	0.0000
DLGDPDEF	0.444903	0.053338	8.341190	0.0000
Mean dependent var	0.033212			
S.D. dependent var	0.043070			
S.E. of regression	0.063888			

[14] This estimate contrasts with the OECD (2012) results, which finds *no* effect of GDP per capita in its sample of rich countries.

[15] We estimate a price elasticity of –0.492 (*t*-statistic = 7.94) and a GDP elasticity of 0.608 (*t*-statistic = 4.21) using PPP-deflated data.

[16] We do a Sargan-Hansen test of over-identification beginning with the results in Table 5b and then including the DLPRICEIV1 instrument from Table 5a. The test statistic is 0.46, which is distributed as a chi square with 1 degree of freedom. The *p*-value is 0.497, which does not reject that the over-identifying restrictions are orthogonal to the stochastic disturbance.

Next, we estimate a dynamic demand model where the left-hand side variable (mobile penetration) is included in the model as a lagged dependent variable. We again used a fixed-effects specification because the econometrics literature recognizes that a random effect will be correlated with the lagged left-hand side variable.[17] A Hausman test of random effects versus fixed effects rejects random effects, with the test statistic equal to 30.5 with 3 degrees of freedom. The *p*-value of the test statistic is 0.0000011, which overwhelmingly rejects use of the random-effects specification. Table 5 shows the estimation results for the fixed-effects specification for the dynamic demand model.[18]

TABLE 5: DYNAMIC DEMAND MODEL WITH FIXED EFFECTS

Dependent Variable: DLPEN
Method: Panel Generalized Method of Moments

Sample (adjusted): 2004Q3 2011Q3
Periods included: 29
Cross-sections included: 17
Total panel (unbalanced) observations: 490
White period instrument weighting matrix
Period SUR (PCSE) standard errors & covariance (d.f. corrected)
Instrument specification: C DLGDPDEF DLPRICEIV1 DLGDPDEF(-1)
DLPRICEIV1(-1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLPEN(-1)	0.778484	0.064494	12.07063	0.0000
DLPRICEDEF	-0.105536	0.049031	-2.152449	0.0319
DLGDPDEF	0.117142	0.034248	3.420453	0.0007

Mean dependent var	0.032521
S.D. dependent var	0.042982
S.E. of regression	0.035398

We estimate the price elasticity of demand to be –0.476 and statistically significant, with a *t*-statistic of 4.29.[19] The estimated elasticity of a change in GDP per capita is 0.529, with a *t*-statistic of 7.92. Thus, both elasticities are similar to the estimates of the static demand models in Table 3 and Table 4.[20]

Our demand estimation finds that fixed effects are necessary in the model specification. Otherwise, biased and inconsistent estimates would result. The estimated price elasticity of demand of approximately –0.50 and the estimated GDP-per-capita elasticity of demand of around 0.45 are both estimated precisely (that is, they are

[17] *See, e.g*., Hsiao (2003) and Baltagi (2008).

[18] The model passes the Sargan-Hansen test of over-identification: the test statistic is 2.38, which is distributed as chi square with 2 degrees of freedom, so the *p*-value of the test is 0.304.

[19] The total effect is –0.1055/(1 – 0.7784), and the *t*-statistic is estimated using the delta method.

[20] We also tested the model specification by including a time trend variable, but its effect is small and not significant (with a *t*-statistic = 0.503). We also included log of population, but again, the effect is very small and not significant (*t*-statistic = 0.456). Lastly, the model passes the Sargan-Hansen test of over-identification, although the *p*-value is 0.055.

statistically significant) and find that economic variables have an important effect on mobile subscriptions.

2.3.3. Econometric Estimation of Mexico's Mobile Prices

We now estimate a price equation for the seventeen countries, using quarterly data for the period from the second quarter of 2004 to the third quarter of 2011. The left-hand side, dependent variable is log of VRPM, which was provided by Bank of America-Merrill Lynch data. This price variable is the same price variable that we used above. We again use a fixed-effects specification because the Hausman specification test statistic is 1238.9, which is distributed as chi square with 4 degrees of freedom, with a *p*-value of 5.8E–267, so use of the random-effects model is rejected with very high probability. We estimate the price equation in first differences—which accounts for the fixed effects. Table 6 shows the estimated coefficients in the price equation.

TABLE 6: ESTIMATION OF FIXED-EFFECTS PRICE EQUATION

Dependent Variable: DLPRICEDEF
Method: Panel Least Squares

Sample (adjusted): 2004Q2 2011Q3
Periods included: 30
Cross-sections included: 17
Total panel (unbalanced) observations: 507
Period SUR (PCSE) standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
C	–0.019626	0.005784	–3.393115	0.0007
DLGDPDEF	0.291911	0.090899	3.211386	0.0014
DCOMPS	–0.018031	0.024332	–0.741043	0.4590
DLPRICEIV1	0.548047	0.141905	3.862078	0.0001

Effects Specification

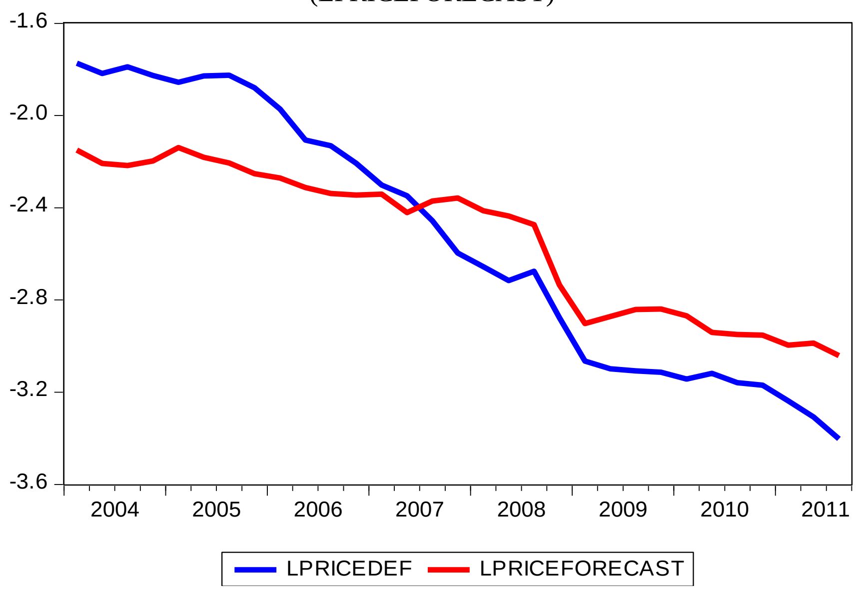
Cross-section fixed (dummy variables)

R-squared	0.238770
Adjusted R-squared	0.209071
S.E. of regression	0.078270

Since the data are in first differences, the constant coefficient represents the effect of a time trend. We find that the price decreases on average by approximately –1.96 percent per quarter or –7.84 percent per year. Increases in log GDP per capita have a positive and significant effect on price. A change in the number of competitors has a small negative effect on prices, but the coefficient is not estimated precisely. The average log price in other countries, DLPRICEIV1, has a large coefficient of 0.548 and is estimated quite precisely (with a *t*-statistic = 3.86). Of all the explanatory variables, the average log price in other countries—which represents changes in cost over time—provides the largest explanation for the decrease in mobile prices over time. For example, for Mexico, the mobile price decreased by 20.4 percent per year from 2004 to 2011. Of this 20.4-percent decrease per year, 5.9 percent per year is explained by this variable.

We now use the fixed-effects results from the price equation to compare the actual mobile price with the "but for" price forecast produced with the estimated price equation. Figure 2 plots the results. Mexico's actual log prices are in blue and decrease at approximately 20 percent per year. Mexico's prices as forecasted by the price equation are in red. From 2004 to 2007, the forecasted prices were below actual prices. However, since 2007, actual prices have decreased more rapidly than have forecasted prices. In 2011, Mexico's actual prices were approximately 36.1-percent below forecasted prices.[21]

FIGURE 2: MEXICO'S ACTUAL (LPRICEDEF) AND FORECASTED AVERAGE MOBILE PRICES (LPRICEFORECAST)



2.3.4. Consumer Surplus Calculation

Mexican consumers are not losing consumer surplus due to high prices, as the OECD (2012) concluded erroneously based on its sample of rich countries and incorrect hypothetical prices. To the contrary, Mexican consumers are currently receiving significant amounts of consumer surplus from these lower prices. We use the estimated coefficients from the demand equation and the results from the price equation to estimate how much better off Mexican consumers are from the lower prices compared with the

[21] To test how robust are our results, we repeat the comparison of Mexico's actual and forecasted mobile prices using alternative estimations. Our results are consistent across the alternative forecasting methods: Mexico's actual mobile prices have fallen below the predicted prices. First, we estimate a model using least squares instead of fixed effects. By 2011, Mexico's actual mobile price was 55.5-percent below the least-squares forecasted price. Second, we repeat this exercise using least squares but remove Mexico from the sample when we estimate the equation. Using this method, we find that Mexico's actual mobile price in 2011 was 59.8-percent below the least-squares forecasted price. Third, we do the same estimation but instead use the PPP-adjusted prices. Under this estimation, in 2011, Mexico's actual mobile prices were 32.3-percent below forecasted prices on a PPP basis. All our estimations show that, when we compare Mexico's average mobile prices with forecasted prices based on other countries' prices and the average of other countries' prices, Mexico has had lower prices since about mid-2006. By 2011, Mexico's actual mobile prices were significantly lower than the forecasted prices, by 32 percent or more.

model's prediction. The formula for the change in consumer surplus using a log-log demand model is given by:

$$\Delta CS = (p_2 q_2 - p_1 q_1)/(1-\varepsilon) \quad (1)$$

where ε is the own-price elasticity of demand (expressed as a positive number), p_1 and q_1 refer to actual mobile price and quantity in 2011, and p_2 and q_2 refer to predicted mobile price and quantity in 2011.[22] For the predicted quantity, we use:

$$q_2 = q_1 \left(\frac{p_2}{p_1} \right)^{-\varepsilon} . \quad (2)$$

Substituting equation (2) into equation (1) and rearranging, the change in consumer surplus can be written as follows:

$$\Delta CS = \left(\frac{p_1 q_1}{1-\varepsilon} \right) \left[(p_2 / p_1)^{-\varepsilon} - 1 \right] . \quad (3)$$

We calculate the change in consumer surplus as a percentage of mobile services expenditures, $p_1 q_1$. For a log-log demand model, this ratio can be derived by rearranging equation (3):

$$\frac{\Delta CS}{p_1 q_1} = \frac{1}{1-\varepsilon} \left[(p_2 / p_1)^{-\varepsilon} - 1 \right] . \quad (4)$$

For the predicted price, we use the lower bound found above from the fixed-effects price forecast that actual prices were 36.1 percent lower than predicted, so $p_2 = p_1/(1 - 0.361)$, and a price elasticity of demand of –0.476 (in absolute terms). We find that the change in consumer surplus is approximately 50.5 percent of mobile service expenditures in 2011. Total mobile revenue in Mexico was \$17 billion (USD) in 2011, of which more than half was mobile voice revenue. Thus, consumers received at least \$4 to \$5 billion in consumer surplus relative to what one would expect based on comparable countries.

2.4 . Fixed-lines telecommunications prices in Mexico and consumer surplus

Using a sample of twelve peer countries, we estimate demand and price models for Mexico's fixed-line sector.[23] We find that fixed-line demand, measured in terms of the number of fixed lines per 100 inhabitants, has exceeded the model's predicted demand since 2004. Since 2005, Mexico's fixed-line prices have been below the model's predicted prices. As a result of low prices, Mexican consumers have received more than \$1 billion (USD) in consumer surplus annually.

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[22] For the development of the consumer surplus equations, see Hausman (2003).

[23] Anomalous price data for five countries required us to reduce the sample size of peer countries.

2.4.1. Econometric Estimation of Mexico's Fixed-Line Demand

We estimate an econometric model of demand for fixed-line services using the data on Mexico's peer countries. We estimate a demand equation for fixed-line service for twelve of the seventeen peer countries using ITU price data for the period from 2000 to 2010. Specifically, we used ITU data on the monthly subscription for residential telephone service which refers to the monthly rental for a residential fixed-line telephone. The ITU monthly subscription for residential telephone data are for those plans without the inclusion of free minutes or calls. Because these data are for tariffs that include only the fixed monthly charges we do not need to account for usage that may be bundled into monthly charges and that can vary among countries. Pricing data from the ITU contained missing and anomalous data for some countries, hence the selection of twelve countries for the sample.[24] The variables that we use are a price variable, GDP per capita, and a time trend. The price variable is the real, inflation-adjusted ITU monthly residential price. Table 7 presents the summary statistics of the variables used in the fixed-line demand regression model.

TABLE 7: SUMMARY DATA STATISTICS USED IN THE FIXED-LINE DEMAND REGRESSION

Summary Statistic	**Fixed Telephone Lines per 100 Inhabitants [1]**	**GDP per Capita (Deflated USD) [2]**	**Monthly Subscription for Residential Telephone Service (Deflated USD) [3]**
Mean	31.19	$9,691	$10.52
Standard Deviation	14.16	$5,961	$4.83
Minimum	5.99	$1,775	$2.96
Maximum	59.24	$24,284	$18.90
N	132	132	123

Sources: World Telecommunication/ICT Indicators Database 2011 (15th ed.); The World Bank.

Table 8 below presents the monthly residential subscription charges in real 2010 US$ and penetration rates for the countries in our sample. Mexico ranks in the middle with respect to prices and ranks low with respect to penetration levels. Similar to our results for mobile services, however, characteristics specific to Mexico (*e.g.,* extent of rural area and makeup, lack of universal service program, *etc*), which are captured by country-specific variables in a fixed effects econometrics specification, help explain Mexico's fixed-line penetration.

[24] The countries that we dropped from the analysis due to missing and anomalous data were Argentina, Chile, Colombia, Poland, and South Africa.

TABLE 8: FIXED-LINE MONTHLY SUBSCRIPTION CHARGE AND PENETRATION BY COUNTRY

Country	Monthly Subscription for Residential Telephone Service (Deflated USD) [1]	Fixed Telephone Lines per 100 Inhabitants [3]
Malaysia	$3.2	16.1
Korea	$3.9	59.2
Russia	$4.0	31.4
Turkey	$7.3	22.3
Peru	$11.1	10.9
Mexico	$11.6	17.5
Israel	$11.8	44.2
Hungary	$13.4	29.8
Greece	$16.0	45.8
Portugal	$16.0	42.0
Czech Republic	$16.8	22.9
Brazil	$18.2	21.6

Sources: World Telecommunication/ICT Indicators Database 2011 (15th Edition).

The demand model that we estimate has the log of fixed-line penetration as the left-hand side, dependent variable. The right-hand side, independent variables are the log of real inflation-adjusted fixed-line price, the log of real inflation-adjusted GDP per capita using market exchange rates, a time trend for the years 2000 to 2010, and time trend squared.

We first estimate a fixed-effects model (model (1) in Table 8), treating price as exogenous. The Hausman test statistic equals 45.47 with 4 degrees of freedom, which rejects the random-effects estimator for this model. We then estimate a fixed-effects model (model (2) in Table 8), treating price as endogenous. The instruments we use follow the same approach used previously. Specifically, we use the average of the log of deflated fixed-line prices of countries other than the country in question for a given observation. A Hausman specification test for the joint endogeneity of price, however, does not reject the hypothesis that price is exogenous. Specifically, the Hausman test statistic is equal to 0.32 with 4 degrees of freedom.[25]

[25] The finding for exogeneity of price in fixed line may well arise, in part, because fixed line prices are set by regulation, not by competition, in some countries in the sample.

TABLE 9: FIXED EFFECTS AND IV REGRESSION RESULTS FOR FIXED-LINE SERVICES

Name of Variable	Model (1) Fixed Effects Estimation Technique		Model (2) Fixed Effects - IV Estimation Technique	
L_fixed_price_real	-0.270	***	-0.368	**
	(0.047)		(0.1776)	
L_gdp_real	0.135	*	0.213	
	(.0717)		(0.156)	
Trend	0.036	**	0.044	**
	(0.0153)		(.021)	
Trend square	-0.003	***	-0.004	**
	(0.001)		(0.002)	
Constant	-1.97	***	-2.472	**
	(0.571)		(1.051)	
Number of Observations (n)	123		123	
F(4,107) / F(11,107)	9.19		42.49	
Chi2	-		17714.01	
R-sq within	0.2556		0.2257	
Instrumented (Variable)	-		l_p_real	
Instruments	-		l_gdp_real, trend, trend square iv_p_real	

Notes:
Standard Errors are presented in parenthesis.
**** statistically significant at 1% level, ** 5% level, * 10% level.*

The own price elasticity of demand for fixed-line service in model (1) is -.270 with very precise standard errors leading to a significant coefficient. The own price elasticity of demand for fixed-line service in model (2) where price is treated as jointly endogenous is -.368, and significant at the 5 percent level.[26] Given that a Hausman specification test does not reject the hypothesis that price is exogenous we rely on model (1). The income elasticity is .13 and significant at the 6 percent level.

The rejection of the random effects models and acceptance of the fixed effects models indicate that unobserved country-specific attributes are important and are likely to be correlated with the exogenous variables and that failure to control for these factors leads to biased estimates and wrong conclusions. What this means in practice is that in an

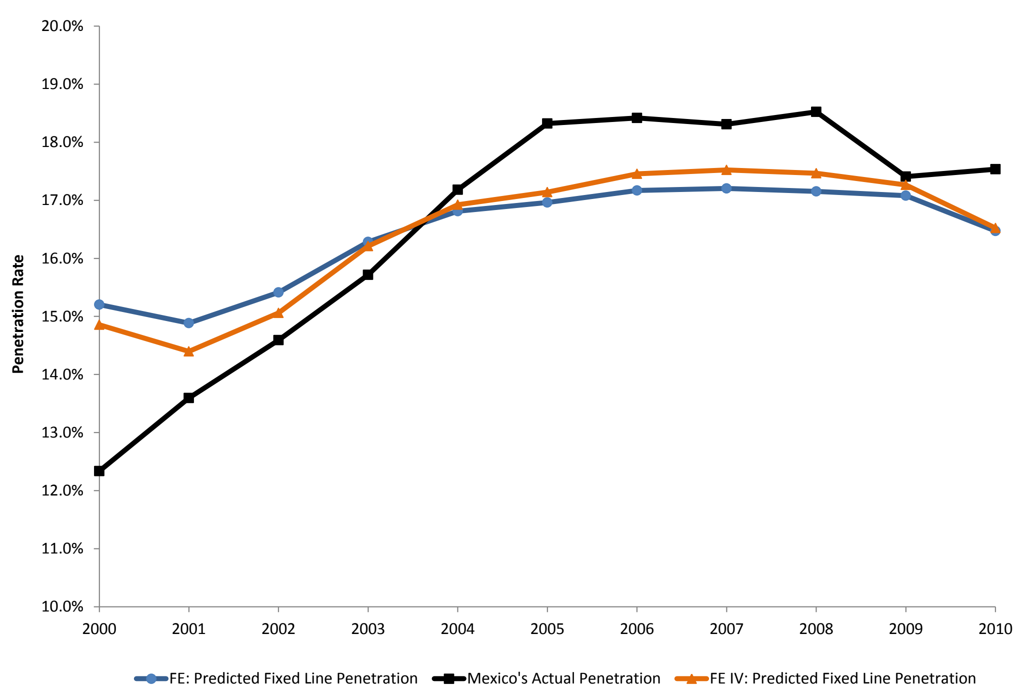
[26] These results are on the high side of previous findings, see Garbacz & Thompson (2007).

econometric regression it is crucial to control for country-specific unobservable factors that are unique and are important determinants of telecommunications demand and prices. Even within this sample of similar countries, there are unique factors that influence telecommunications demand that must be accounted for. The OECD (2012) models do not control for this and, as a result, produce incorrect parameter estimates and conclusions. Econometrically, the OECD (2012) assumes that the constant term for each country is identical, an assumption that our regression model rejects.

The results of the model can be used to compare Mexico's actual fixed-line penetration with predicted levels. Figure 3 shows that in the early years Mexico's actual fixed line penetration was below its predicted. Beginning in 2004, however, Mexico's actual penetration was above its predicted, reaching a high of 1.4 percentage point difference in 2008 and averaging approximately 1.0 percentage point difference between 2004 and 2010.

The results in Figure 3 show that Mexico's fixed-line penetration is not low by international standards when compared to a sample of similar countries and when performing correct econometric modelling. In fact, Mexico performs quite well. The results also make clear that it is important to control for GDP per capita and that even within this sample of countries it is important to control for unique factors in Mexico. Our findings refute the OECD (2012) conclusions that Mexico should have had 3.6 times as many fixed lines in 2000 and an average of 2.6 times as many fixed lines between 2000 and 2007.

FIGURE 3: ACTUAL FIXED-LINE PENETRATION RATE IN MEXICO AND PREDICTED FIXED-LINE PENETRATION RATE FROM PEER REGRESSION ANALYSIS



Sources: World Telecommunication/ICT Indicators Database 2011 (15th Edition); The World Bank.

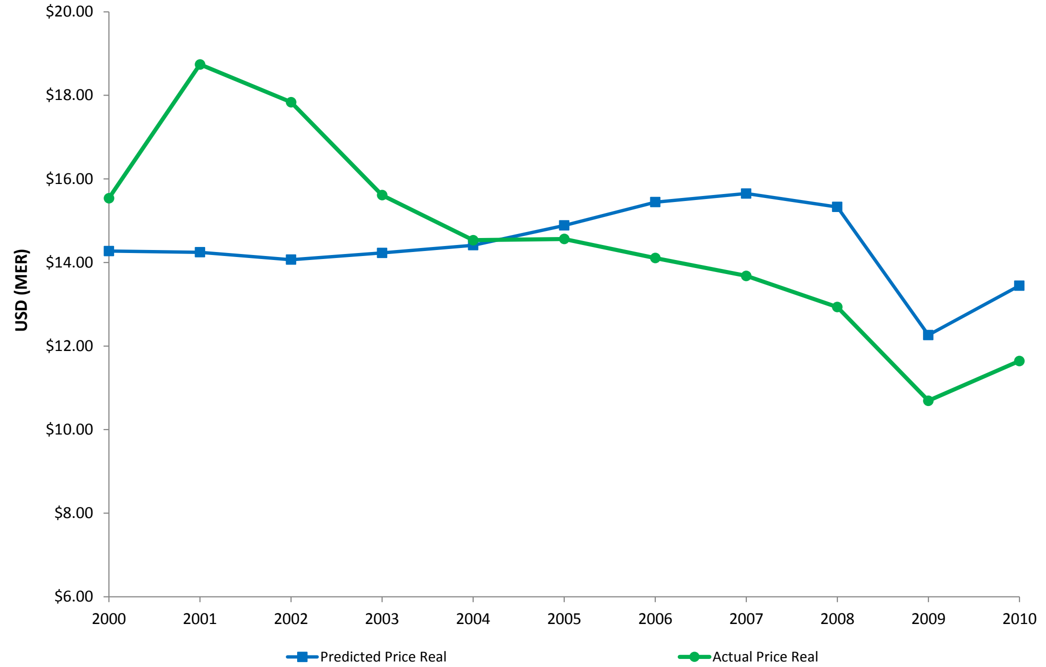
2.4.2. Econometric Estimation of Mexico's Fixed-Line Prices

We now estimate an equation for fixed-line prices in Mexico. Specifically, our dependent variable is the log of real price of residential services and our independent variables are the log of real GDP per capita and a time trend, to control for cost changes over time. Similar to the demand model, we estimate a model using fixed effects. The Hausman test statistic is equal to 11.76 with 2 degrees of freedom which rejects the random effects estimator for this model and again confirms the importance of taking into account and controlling for each country's unique determinants of fixed-line prices. The coefficient estimate for GDP per capita is 0.8726 estimated very precisely with a standard error of 0.1322. A one percent increase in real GDP per capita leads to a 0.87 percent increase in real price. This finding provides additional evidence that GDP per capita is an important determinant of demand. The coefficient for the time trend is -0.0246 estimated precisely with a standard error of 0.0116. Real fixed-line prices in our sample of countries are trending down at a rate of about 2.5 percent per year.

We now graph Mexico's actual real residential fixed-line prices and predicted in Figure 4. Actual fixed-line prices in Mexico were above predicted prices between 2000 and 2004 by an average of 12.6 percent. The trend changes, however, in 2005, at which point Mexico's actual prices were below predicted prices by an average of 12.5 percent between 2005 and 2010. In 2010, actual prices were 13.4 percent below predicted prices. The results in the figure show that Mexico's fixed-line prices are not high by international standards when compared to a sample of similar countries and when performing correct econometric modeling. In fact, Mexico performs quite well. The results also make clear that it is important to control for GDP per capita and that even within this sample of countries it is important to control for unique factors in Mexico. Our findings refute the OECD (2012) conclusion that by 2007 Mexico's fixed-line prices should be about 25 percent lower than actual prices.[27]

[27] OECD (2012) p. 44 tbl.39.

FIGURE 4: ACTUAL FIXED-LINE PRICES IN MEXICO COMPARED WITH PRICES PREDICTED BY PEER REGRESSION ANALYSIS



Sources: World Telecommunication/ICT Indicators Database 2011 (15th Edition); The Bureau of Labor Statistics.
Note: The complete name of the price variable is "Monthly subscription for residential telephone service (US$)." This variable has been deflated by the US "Consumer Price Index." The base year used for real prices is 2000.

2.4.3 Consumer Surplus Calculation

We use the results from the fixed-line demand equation to estimate how much better off Mexican consumers are from the lower prices compared to the model's prediction. The methodology used is the same as in the calculation of consumer surplus for mobile consumers described above. As described above, the change in consumer surplus as a percentage of total expenditures of fixed-line services, p_1q_1, for a log-log demand model is given by (4) above, rewritten here for convenience:

$$\frac{\Delta CS}{p_1 q_1} = \frac{1}{1-\varepsilon}\left[(p_2/p_1)^{-\varepsilon} - 1\right]. \qquad (4)$$

For predicted price we use the fact that actual prices were 13.4 percent lower than predicted, so p2=p1/(1-0.134) and use a price elasticity of -0.270 (in absolute terms). When we plug into equation (4) the price ratio and the price elasticity, we find that the change in consumer surplus is about 15 percent of fixed-line expenditures. Total fixed-line revenue in 2010 was approximately $7.5 billion (USD). Thus, consumers received more than $1 billion in consumer surplus relative to what one would expect based on comparable countries.

3 CONCLUSION

We analyzed telecommunications prices in Mexico by using a panel data of countries similar to Mexico to estimate demand models for mobile and fixed-line telecommunications. Contrary to findings in a recent report, we find that prices in Mexico are far below the average prices in other comparable countries (including nine OECD countries) and lowest in our sample of Latin American countries. The fixed-line sector performs better than a comparable sample of peer countries. Mexican consumers are receiving billions of dollars of benefits from these lower prices.

The results are counter to the perception that since Mexican telecommunications markets are generally more concentrated than telecommunications markets in other OECD countries consumers are being harmed. Indeed, regulators in Mexico and other Latin American countries are contemplating asymmetric regulation of the dominant mobile operator including regulation of retail mobile prices. Our findings suggest that prior to the imposition of regulations (especially retail price regulations) regulators should examine all economic factors that are important determinants of market power including market share, supply elasticity, and demand elasticity. Market share alone can be misleading.

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