Measuring the effects of mobile number portability on service prices

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Abstract Increasing numbers of countries require mobile telephone networks to offer mobile number portability (MNP). MNP allows customers who wish to switch mobile operator to keep their mobile numbers, avoiding the costs of switching to new numbers. *Ex ante* assessments suggest that MNP should reduce switching costs and strengthen competition. In this paper, the author tests MNP's impact on mobile telephony retail prices using international time-series cross-section data. It is found that MNP reduces average prices when the switching process is rapid (less than five days) but not when it is slower.

KEYWORDS: mobile telephony, cost–benefit analysis, competition, switching costs

PRINCIPAL MANAGEMENT IMPLICATIONS

- Regulations requiring operators to provide mobile number portability reduce service prices if porting times are sufficiently rapid.
- The effect takes about a year to feed through to prices.
- There is no evidence of price effects from slower porting times.
- Consumer switching costs have significant effects on mobile telephony demand.
- Regulators are justified in including 'Type 2' competitive benefits when considering the likely effects of mobile number portability regulation.

INTRODUCTION

Increasing numbers of countries require mobile telephone network operators to offer mobile number portability (MNP). This facility allows customers who wish to switch mobile operator to keep the mobile numbers originally assigned to them, avoiding the costs of switching to new numbers. Since MNP regulation was first mooted, policy makers have asked whether it can produce positive net benefits. *Ex ante* evaluations of MNP carried out in several countries have produced detailed estimates of expected costs and direct benefits (eg the savings accruing to customers from lower switching costs). While researchers have suggested MNP should have a range of potentially important effects, such as strengthened competition and reduced prices, few attempts have been made to quantify them *ex post*.[1] The staggered introduction of MNP internationally provides a useful natural experiment.

In this paper, econometric analysis of international time-series cross-section data is used to estimate the average treatment effects of MNP on retail prices. The dataset constructed for this purpose includes information from 30 countries for up to 29 quarters (first quarter 1999 through to first quarter 2006). It is found that the quality of MNP, as proxied by the target maximum porting time, helps to explain its impact on average prices. For countries in the sample that required porting to be completed in five or fewer days, MNP was associated with lower prices. The sub-sample of countries with less stringent porting time standards experienced no significant price effects.

The costs associated with the MNP service depend upon the technology used to deliver it. The technology, in turn, determines the 'quality' of MNP, including dimensions such as porting time and reliability. Previous research has emphasised the importance that the choice of number portability technology has in determining the likely effects of the measure.[2] The results provide empirical support for this view. Jurisdictions conducting *ex ante* assessments of MNP in the future should consider the likely trade-off between achieving positive market outcomes and the cost of implementation.

The second section of the paper provides a brief classification of the potential benefits of MNP and refers to some previous research, including both *ex ante* cost–benefit studies and other empirical research. The third section asks what effects MNP should be expected to have on retail prices. The dataset constructed for this study is described in the fourth section, along with some descriptive statistics. The fifth and sixth sections set out econometric models of switching and retail prices, respectively, and the final section discusses the conclusions and suggestions for future research.

POTENTIAL BENEFITS OF MNP

To provide the context for the empirical analysis that follows, this section briefly reviews some relevant empirical research. This consists of *ex ante* cost–benefit analyses conducted on MNP by regulators and a modest number of *ex post* empirical studies. Existing theoretical research on MNP was recently surveyed,[3] but to clarify terminology used in the remainder of the section, it is worth restating the standard classification of number portability benefits.

Classification of benefits

A commonly-used approach to analysing the likely costs and benefits of MNP divides the measure's potential benefits into three types:[4,5]

- *Type 1* benefits obtained directly by customers who switch;
- *Type 2* benefits obtained by all mobile telephony customers (eg efficiency gains and price reductions due to strengthening of competition); and
- *Type 3* benefits obtained by those making calls to ported numbers.

Past *ex ante* evaluations have proceeded on the basis that MNP should be expected to provide net welfare gains if the sum of these benefits exceeds the cost of network investments, process changes and operating expenses incurred to make mobile numbers portable. However, they have tended to focus on the more empirically tractable Type 1 and Type 3 benefits, giving less emphasis to Type 2 benefits. The following section reviews some of the results of these *ex ante* evaluations.

Ex-ante cost–benefit analyses

Full MNP was first employed in Singapore in 1997, and since then many countries have introduced this form of regulation. Several cost–benefit analyses are available in published form, notably for the UK,[6] Hong Kong[7] and Ireland.[8] Table 1 summarises the estimated benefits per customer by type from each of these studies.

Type 2 benefits were viewed as difficult to estimate, and since Type 1 benefits were by themselves expected to be sufficiently high to justify the intervention, Type 2 benefits were either not quantified or subject to only simple scenario analysis. For example, the cost–benefit analysis for the Irish market assumed that MNP

Table 1: Predictions from three *ex ante* assessments of MNP

Country	*UK*	*Hong Kong*	*Ireland*
Base year	*1997*	*1998*	*2000*
*Expected benefits per subscriber**			
Type 1	28–81	39–71	78
Type 2	n/a	1	26
Type 3	1–5	1–3	5

* Present value (in US$) of ten-year impact divided by subscribers in base year.
Exchange rates are base year figures from the International Monetary Fund (IMF) International Financial Statistics Online (http://www.imfstatistics.org/imf)..
Sources: Analysis of estimates from OFTEL (1997) 'Economic Evaluation of Number Portability in the UK Mobile Telephony Market', OFTEL, London; National Economic Research Associates and Smith System Engineering (1998) 'Feasibility Study and Cost Benefit Analysis of Number Portability for Mobile Services in Hong Kong', final report for OFTA, NERA, London; Ovum (2000) 'Mobile Numbering and Number Portability in Ireland: A Report to the ODTR', Ovum, London.

would lead to a 3 per cent fall in retail post-pay mobile telephony prices. Sensitivity analysis was carried out for reductions of 1 per cent and 5 per cent. The study also noted that there might be benefits from cost efficiencies or greater innovation, but these were not modelled.

Other empirical research on the effects of MNP

There has been limited quantitative analysis of MNP's impact, normally treating the intervention as homogeneous in quality. A recent paper on the determinants of mobile average revenue per user found no significant impact from MNP.[9] Another study modelled supply and demand of mobile telephony services using European panel data and tested for the impact of various policy measures including MNP.[10] It found that MNP had a significant negative impact on prices in the supply equation, but no significant demand-side effect. However, this paper applied static panel data estimators to price and penetration data that are (as shall be seen later) subject to considerable inter-temporal persistence. No tests for residual autocorrelation were reported, so it is impossible to assess the robustness of this result.

A different strand of *ex post* empirical work on MNP has focused on the propensity of those switching mobile provider to use MNP. This is particularly relevant to the size of Type 1 benefits as discussed above.

As part of a wider study of switching costs for the UK Office of Fair Trading, NERA examined the usage of MNP for inter-operator switching in UK mobile telephony markets.[11] It was found that, in the first two years after MNP was introduced, the usage of MNP was very limited for residential customers, with only 12 per cent of customers who switched operator taking up the portability option. This is far lower than the rate predicted in *ex ante* assessments; however, half of the businesses that changed numbers in this period ported at least some of their numbers. NERA suggested that the difficulty of using MNP during the first years after implementation might explain its unpopularity: porting a number originally took an average of 25 days. When the delivery time was reduced to five days on average, take-up increased to about 18 per cent for residential customers and 80 per cent for businesses.

Looking beyond the propensity of switchers to use MNP, there has been little previous empirical work on the broader effects of MNP regulation. One study examined the experience of MNP in six countries that have implemented it: Australia, Germany, Hong Kong, Ireland, the Netherlands and the UK.[12] Several of its findings are relevant to this study:

- Usage of MNP can fall significantly if the time it takes to change operator ('porting time') is too long. The authors suggest that two days is a practical upper limit; however, very short porting times do not necessarily increase demand for MNP.

- High end-user charges for MNP can also deter usage of the facility. Lower charges, which the authors suggest are levels of less than 20 per cent of monthly average revenue per user, do not seem to be a 'major deterrent to usage'. However, zero charges do not seem to increase demand beyond the levels associated with low charges.
- In jurisdictions with MNP, the extent to which switching customers use it varies widely and tends to increase over time.

There has also been a limited amount of academic research on individual markets. Below two are cited concerning MNP and one on number portability in a related market.

The first used contingent valuation techniques to estimate the prospective demand for MNP in South Korea.[13] It found that the average South Korean mobile user was willing to pay an average of 3.24 per cent of their monthly bill for an MNP option. Willingness to pay (WTP) showed a strong positive association with income, awareness of MNP and intention to switch. The authors also found that WTP varied significantly depending upon a user's network operator: the figure was lower for customers of the incumbent operator than those using either of the alternative operators. Other demographic variables such as age, gender and occupation were not found to be significant.

A recent *ex post* study of MNP's effects also focuses on South Korea.[14] This study estimated switching costs for customers of two of the country's mobile network operators by applying a random utility model to cross-sectional subscriber-level microdata. The paper compared switching costs calculated using samples before and after MNP, and differences between these estimates were attributed to MNP. Controls included firm-specific dummy variables, prices, non-price network attributes and customer characteristics. MNP was found to have reduced average switching costs in South Korea by more than 35 per cent. Data reported in the paper indicate that there was significantly more switching after MNP was introduced, at least among customers of the largest operators. Service fees maintained a downward trend of about 7 per cent per annum from 2002 to 2005, with no obvious change in relative or absolute prices at the point MNP was introduced for the two largest operators (July 2003). Per-minute prices remained broadly unchanged over the period.

Another study examined the effect of number portability on prices in the US market for toll-free calls.[15] This service is different from mobile telephony, but it is similar in some respects (eg high rates of growth).[16] Estimating price regressions on data from 219 AT&T virtual private network contracts, the study found that introduction of number portability was associated with a price reduction of 4.4 per cent. A control group of contracts containing no toll-free services showed no relationship between prices and the introduction of number portability. The author interpreted the results as evidence of an inverse relationship between switching costs and competition in this market: 'despite rapid growth in the market, the firms' incentive to exploit their existing ''locked in'' users was greater than their incentive to ''lock in'' new customers'.[17]

LIKELY EFFECTS OF MNP ON RETAIL PRICES

This section outlines the main effects that economic theory suggests MNP should have on retail prices. The net effect of MNP on retail prices in principle is indeterminate. Empirically, it is likely to depend upon the interplay of three groups of effects:

- pass-through of costs associated with the facility (increase in prices);
- effects on competition (probably a decrease in prices); and
- loss of customer information (increase in prices).

First, and most obviously, the implementation of MNP imposes costs on all operators employing it. Depending upon the extent of competition in a given national market, these costs are likely to be (at least partly) passed on to consumers and thereby lead to increased prices. Some argue that this is likely to be the main effect of number portability, and hence that mandating it through regulation will lead to a net reduction in welfare.[18] Aoki and Small (1999) also address the welfare impact of switching cost reductions due to number portability.[19] They identify cases in which switching cost reductions provided by number portability (eg reducing the need to purchase complementary goods such as stationery) could be offset by higher marginal costs of providing call services, leaving consumers with lower surplus.

Beyond the simple effect of increased direct costs from implementation of MNP, theory is less definite about the effect of decreased switching costs on prices. A survey on the effects of consumer switching costs on competition concludes that 'switching costs generally raise prices and create deadweight losses of the usual kind in a closed oligopoly'.[20] Another paper that proposes a switching model focusing specifically on MNP yields an overall reduction in prices for customers but implies that increases for entrants' customers will be more than offset by decreases for incumbents' customers.[21] The switching cost literature also raises the possibility that a fall in switching costs could make it easier to sustain tacit collusion.[22]

The third group of effects concerns an informational channel through which MNP may lead to increases in at least one component of mobile telephony prices. Depending upon how MNP is implemented, it may reduce the tariff information available to both fixed and mobile customers wishing to make calls to mobile numbers.[23,24] Particularly if mobile termination rates are unregulated and there is no mechanism identifying the terminating operator to each caller, such a decrease in transparency could lead to higher prices for call termination.

DATA EMPLOYED

An unbalanced time-series cross-section dataset was constructed including most of the Organization for Economic Cooperation and Development (OECD) countries and a selection of developing countries. It was based principally on the Merrill Lynch Global Wireless Matrix.[25] Although this source provides some data on 47 countries, there are many gaps. To ensure that the data are of reasonable quality and provide an adequate representation of market conditions, only country-quarter observations were included for which the Merrill Lynch dataset contains data on operators supplying at least 80 per cent of subscribers in the market. Also, it was found that data for three countries — China, the Czech Republic and South Korea — contained implausibly large fluctuations in reported subscriber numbers. As a result, these countries were excluded from the dataset. The available panel includes data on 30 countries. The Appendix shows details of the countries and the sample coverage.

The data are quarterly, running for up to 29 quarters from first quarter 1999 through to first quarter 2006. The first two quarters were omitted to allow use of differenced and lagged variables. Table 2 lists the variables and provides summary statistics. Figures in this table and elsewhere in the paper are rounded to three significant digits. Further information on some of the variables is provided in the Appendix.

Gross domestic product in real US$ terms per capita (RGDPPC) was calculated for OECD countries based on local currency real GDP figures and GDP deflators from the OECD Quarterly National Accounts database (http://www.oecd.org/documents/16/0,3343,en_2649_34261_2010768_1_1_1_1,00.html). Exchange rates were taken from IMF International Financial Statistics Online (http://www.imfstatistics.org/imf/). Figures for non-OECD countries were taken from the IMF World Economic Outlook database, April 2007 (http://www.imf.org/external/pubs/ft/weo/2007/01/data/index.aspx), and are annual data, rather than quarterly. These variables were downloaded on 24th May, 2007. Using annual GDP for non-OECD countries is not ideal, but as no quarterly national accounts data were available for these countries it was unavoidable.

Table 2: Variable descriptions, sources and summary statistics (individual observations are for country *i* and quarter *t* in each case)

Variable	Description	Source	Mean	Std Dev.
MNP_{it}	= 1 if MNP in place at any time in quarter *t*	See the Appendix	0.362	0.481
$MNPtime_{it}$	Target maximum single line porting period (days)	See the Appendix	2.86	5.79
$MNP5d_{it}$	If MNP = 1 and *MNPtime* =5 then 1, else 0	See the Appendix	0.182	0.386
$MNP6p_{it}$	If MNP = 1 and *MNPtime* >5 then 1, else 0	See the Appendix	0.181	0.386
RPM_{it}	Average real revenue per minute for MNOs in country *i* (US$)*	Weighted average of individual MNO data from ML	0.209	0.0717
$TOTMIN_{it}$	Monthly average minutes of mobile telephony traffic in country *i* (millions)	Analysis of ML	3,120	3,190
$PDNST_{it}$	Population density: population per km^2	WB	123	148
$RGDPPC_{it}$	Real GDP per capita (US$)	See text above	20,400	12,800
HHI_{it}	Herfindahl–Hirshman Index: sum of the squares of the market shares (users) of all MNOs in country *i*	Analysis of ML	3,770	1,050
OPS_{it}	Number of MNOs in country *i*	Analysis of ML	3.81	1.31
$CR1_{it}$	The top MNO's share of total users	Analysis of ML	0.478	0.117

* Rebased to year 2000 prices using GDP deflators and excluding revenue from data services
Notes: MNO: mobile network operator; ML: Campbell, G. and Chen, F. (2006) 'Gems in the Rough', Merrill Lynch Global Wireless Matrix 1Q06, Bank of America Merrill Lynch, New York; WB: World Bank 'World Development Indicators, 2007', The World Bank, Washington, DC.

MODELLING THE EFFECT OF MNP ON PRICES

The cross-country data available for estimating the effect of MNP on retail prices limited the study to a relatively simple reduced-form modelling strategy. In particular, it was not possible to maintain the standard access/usage distinction and other more complex features of telephony demand models. As a consequence, the model consists of an inverse demand equation for mobile telephony services, with the average price per minute of mobile service as a function of demand and supply-side variables. The elements of the model are described in this section.

The price variable

The proxy for prices is quarterly real average revenue per minute (RPM). It is an aggregate measure encompassing all revenues associated with mobile voice services in each country (but excluding revenue from data services). Use of an average revenue proxy for prices involves a departure from the approach used by most other analyses of regulatory impact on prices in the mobile sector.[26] Prices are more commonly measured for a specified service bundle (eg three minutes of calling time).

RPM has some advantages as a price proxy. For example, it has already been noted that charges for service components such as handsets and call termination may be affected by MNP, and these might not be captured if the focus was on some other measure, such as the average price of a three-minute call or the price of a bundle of 'X' minutes. The benefits of aggregation come at a price. In particular, previous research into telephony demand has highlighted differences in the determinants of demand for network access and network usage (ie calls). RPM aggregates these differences away. Other potentially important features of telephony pricing are also obscured by averaging, including handset subsidies, time of day effects, innovation in tariff structures (eg bundling schemes and pre-payment offerings) and the mix of different call types (eg national versus international).

Explanatory variables

In common with other utility services, the presence of switching costs, brand effects and term contracts in mobile telephony suggests that there may be persistence in demand across time. To allow for such effects, it is important to incorporate dynamics in the model, and this is done by including a lagged dependent variable.

It was noted earlier that both the imposition of MNP and higher quality of MNP might be expected to lower retail prices via a reduction in consumer switching costs. The proxy for quality is the target maximum porting time (MNPTM) in force in a given country. Data on actual, rather than target, porting times would probably be a better measure of quality, but unfortunately these data are not made public in most countries so there is no theoretical prior expectation as to the functional form of the relationship between prices and the quality of MNP.

To identify the quality effect, the study distinguished between countries with an MNPTM of five days or less (for which MNP5D was set to 1) and those with six days or more (for which MNP6P was set to 1). Both variables were set to zero for all other cases. This divides the observations where MNP was in place into two roughly equal parts along the quality dimension.

Table 3 shows how the average of RPM, the proxy for price of mobile services, varies in the sub-samples with and without MNP. These statistics paint a surprising picture, inasmuch as MNP appears to increase prices; however, these descriptive statistics may be misleading. First, there is a declining trend in mobile telephony prices across all countries during the period, and where MNP was implemented it tended to come later in the time series. This timing effect will tend to bias the MNP averages downwards. A similar downward bias may arise because there is a positive association of MNP with quantity of call minutes sold and a negative relationship between quantity and price. In contrast, GDP is positively associated with both MNP and prices, which could lead to an upward bias in the average. To isolate the effects of MNP from other variables, the study had to turn to regression analysis.

Table 3: Relationship between average prices (real revenue per minute) and MNP

Case	*Sample mean real revenue per minute (US$)*
No MNP	0.201
MNP delivery time ≤ 5 days	0.210
MNP delivery time 6+ days	0.236

Source: Merrill Lynch ‘Global Wireless Matrix Q1 2006’, 27th June, 2006, Merrill Lynch, New York.

The coefficients on MNP variables in the price models are expected to be negative, reflecting stronger competition in markets with lower switching costs. An important potential determinant of prices is the quantity of telephony services purchased in each market; one would expect to observe a negative relationship between quantity of services purchased and prices. The proxy for quantity, which has been used by other researchers,[27] is the total quantity of calling minutes supplied. This quantity variable is designated *TOTMIN*, and it too is taken to be endogenous to allow for the simultaneous determination of quantities and prices.

The intensity of competition in each market may also affect pricing. While competitive pressure cannot be directly observed, market concentration may be used as a proxy for it. Three measures of market concentration, the Herfindahl–Hirschman index (*HHI*), the one-firm concentration ratio (*CR1*) and the number of network operators (*OPS*), were tested alternately in the regression since the wish was not to prejudge the nature of the competition in the market. If greater concentration implies weaker competition in mobile telephony markets, *HHI* and *CR1* should have positive coefficients when each of them is included, and *OPS* should have a negative one.

Population density (*PDNST*), a proxy for local cost conditions, should have a negative coefficient reflecting economies of density. Real GDP per capita (*RGDPPC*), a proxy for income, might take a positive coefficient on the grounds that customers in high income areas will exhibit less price sensitivity, leading to higher prices in such areas.[28] Both of these variables might have a non-linear relationship to average prices, so higher order terms were included in the regression.

A time trend (*TIME*) was also included to allow for time-varying unobserved effects and quarterly dummies to capture seasonal variations in pricing policies and demand patterns.

Detailed information on service characteristics is not readily available on an internationally comparable basis. However, since time-series cross-section data are available, characteristics that are jurisdiction-specific may be captured by the use of individual effects.

Other potentially relevant variables were unavailable for the relevant set of countries and periods, including details of marginal price schedules, prices of substitutes (eg fixed-line services), differences in contract terms, quantities of spectrum allocated in each country, the extent of trans-national ownership or control of operators, availability and relative importance of pre-paid services, advertising expenditure, and regulatory variables other than MNP (eg requirements to offer wholesale roaming or access to service providers).

A disturbance term (ε_{it}) and control for individual effects at country level (u_i) were included. Logs were taken of continuous variables, including *RPM*.

To summarise, for country $i = 1 \ldots 30$ and quarter $t = 1 \ldots 27$:

$$\ln(RPM_{it}) = \alpha + \beta_1 \ln(TOTMIN_{it}) + \beta_2 HHI_{it} + \beta_3 \ln(PDNST_{it}) + \beta_4 \ln(PDNST_{it})^2 + \beta_5 \ln(PDNST_{it})^3 + \beta_6 \ln(RGDPPC_{it}) + \beta_7 \ln(RGDPPC_{it})^2 + \beta_8 Q1_{it} + \beta_9 Q3_{it} + \beta_{10} Q4_{it} + \beta_{11} TIME_t + \beta_{12} \ln(RPM_{i(t-1)}) + [\beta_{13} MNP5D_{it} \text{ or } \beta_{14} MNP6P_{it}] + u_i + \varepsilon_{it}$$

The summary of prior expectations about coefficients is:

$$\beta_2, \beta_4, \beta_6, \beta_{13}, \beta_{14} > 0;$$
$$\beta_1, \beta_3, \beta_5, \beta_7, \beta_{11} > 0$$
$$0 < \beta_{12} < 1$$

Econometric results

This section estimates the model as described above. Because a dynamic panel data model was being employed, the models were estimated using the Arellano–Bond 'difference GMM' estimator with robust standard errors. This also allowed for endogeneity of the quantity variable using Arellano–Bond instruments. Lags of between 0 and 8 quarters were tested on the MNP variables, and the signs were the same in all cases, although statistical significance varied. Table 4 sets out the regression results for a four-quarter lag.

Evidence was found that MNP reduces retail prices, but only when its quality is high. For those countries with MNP delivery times of five days or less, the estimated short-run effect of implementing MNP was a fall in real average prices of about 8–9 per cent. The estimated long-run reduction was significantly higher, at 12–15 per cent. Depending upon the lag length, the MNP coefficient for countries with longer (6 + days) MNP delivery times was sometimes positive and sometimes negative; however, in no case was it significantly different from zero. A statistically significant difference was found between the values of the two MNP dummies ($^2(1) = 5.07$ [0.0244] in the four quarter lag model), which further supports the idea that increasing the quality of MNP reduced prices.

Figure 1 illustrates the development of the MNP effect over time for the =5-day delivery standard. While the central estimate of the coefficient is negative for all lags, it becomes significant and stabilises at around 8–9 per cent for lags of 4–8 quarters.

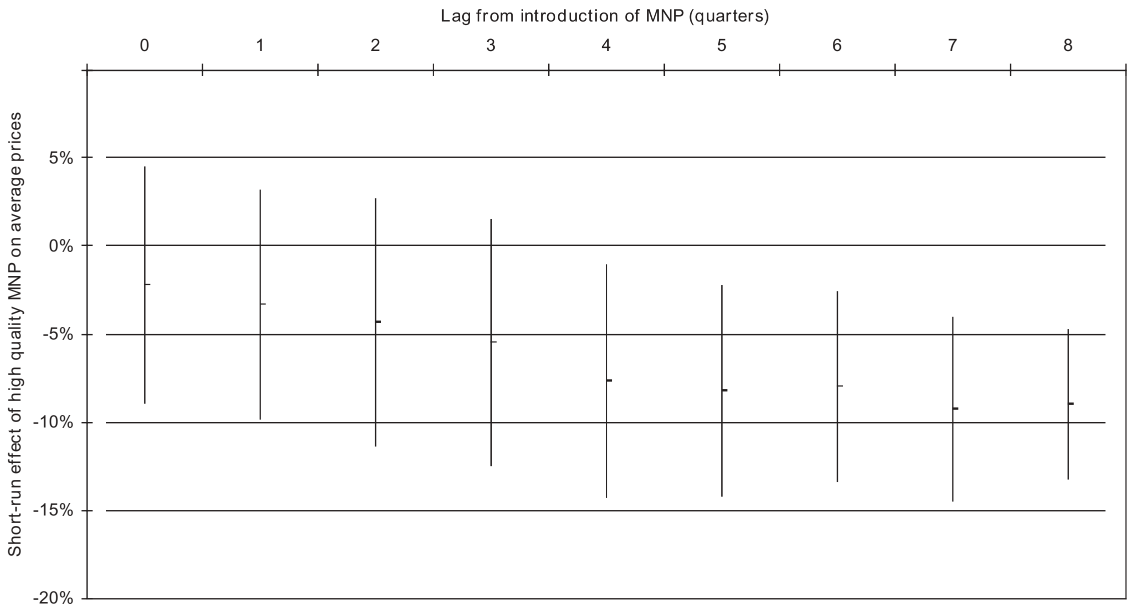
As expected, a robust inverse relationship was found between the number of minutes of traffic and real average prices. The coefficient on lagged prices was positive and less than one, indicating significant inter-temporal persistence in mobile telephony prices. Income also had the expected (positive) sign. Neither *LHHI* (shown above) nor alternative proxies for market concentration (*CR1* and *OPS*) proved to be significant. Evidence was found of lower average prices in the first quarter of each year, perhaps reflecting the effect of temporary discounts on packages sold in the fourth quarter. There was also some evidence that prices have a negative trend over time.

Not all coefficients performed as expected.

Table 4: Price regression results using Arellano–Bond estimator, with a four-quarter lag on MNP (*LTOTMIN* is treated as endogenous)

Variables and statistics	*All variables*		*Preferred model*	
Dep. variable	$LRPM_{it}$		$LRPM_{it}$	
	Coef.	*Robust Z-stat.*	Coef.	*Robust Z-stat.*
$LRPM_{i(t-1)}$	0.373	3.31***	0.383	3.15***
$MNP5d_{i(t-4)}$	–0.0710	–2.18**	–0.0766	–2.29**
$MNP6p_{i(t-4)}$	0.0248	1.01	0.00985	0.44
$LTOTMIN_{it}$	–0.277	–4.67***	–0.228	–4.79***
$LHHI_{it}$	–0.0262	–0.88		
$LPDNST_{it}$	2.26	2.02**		
$LPDNST^{2}_{it}$	–0.292	–2.01**		
$LRGDPPC_{it}$	1.38	2.68***	0.641	4.65***
$LRGDPPC^{2}_{it}$	–0.0409	–1.67*		
$Q1_{it}$	–0.0431	–5.95***	–0.0421	–5.87***
$Q3_{it}$	0.0265	3.43***	0.0265	3.49***
$Q4_{it}$	–0.00281	–0.35	–0.00730	–1.03
Time trend	–0.00661	–1.91*	–0.00847	–2.36**
Constant	–11.9	–2.68***	–5.34	–4.02***
Sample	30 countries		30 countries	
Observations	538		538	
Min. periods	2		2	
Avg. periods	17.9		17.9	
Max. periods	27		27	
Instruments	491		489	
Wald χ^2 (13)	7,000			
Wald χ^2 (9)			9,350	
Arellano–Bond residual serial correlation test, order 2	Z = –0.1.53 [0.125]		Z = –1.50 [0.134]	

Note: All variables are in first differences apart from the constant, and variables with an 'L' prefix are in log terms. Figures in italics are *t*-statistics; *, ** and *** denote significant at the 10%, 5% and 1% level respectively. Numbers in brackets are *p* values.
Sources: Campbell, G. and Chen, F. (2006) 'Gems in the Rough', Merrill Lynch Global Wireless Matrix 1Q06, Bank of America, Merrill Lynch, New York; World Bank 'World Development Indicators, 2007', The World Bank, Washington, DC.



Note: MNP effect is for jurisdictions with ≤5-day delivery standard; results are based on preferred model shown in Table 4

Figure 1: Short-run effect of MNP on average prices for varying lag lengths (vertical bars show extent of 95 per cent confidence interval)

After testing the model it was found that the squared income term and both population density terms were jointly insignificant. (A Wald test for joint zero coefficients on *LHHI*, *LRGDPPC2*, *LPDNST* and *LPDNST2* was not rejected: $^{2}(4) = 5.07$ [0.280].) The study also tried including churn (the ratio of monthly disconnections to total network subscriptions in a given month) as an explanatory variable, on the basis that high churn could increase the average cost of providing service or could reflect high intensity of competition; however, it was not significant.

CONCLUSIONS

The central finding is that prices fell in countries with a five-day or better MNP delivery standard after a lag of roughly one year, as summarised in Table 5. The price result can be compared to Viard's finding that there was a 4.4 per cent fall in prices after the introduction of toll-free number portability, which is a different but similar service.[29]

No significant effect of MNP was found on average prices for countries that applied a less stringent target for maximum porting time. For jurisdictions requiring 'high-quality' MNP, the results are consistent with the presence of significant Type 1 and Type 2 benefits.

From a regulatory perspective, these findings support the argument that imposing MNP in a market can reduce retail prices by reducing consumer switching costs. Reducing switching costs provides direct benefits to those switching and indirect benefits via an increase in the intensity of competition. Both types of benefit should be taken into account by jurisdictions considering imposition of MNP rules. However, a second important message for regulators is that the quality of the MNP process, in particular, the time taken for porting numbers, must be sufficiently high for these potential price reductions to be realised. There may be a trade-off between this source of benefits and the cost of the porting system, which is worth considering when carrying out future cost–benefit analyses of MNP obligations.

There are implications for mobile network operators too; in particular, equilibrium retail prices are likely to fall following the imposition of an effective MNP system. This may not be an immediate effect: these results suggest that it takes some time for a market to adjust fully to the lower level of switching costs, with a lag of about a year in the full effect on prices. Of course, the timing of the effect in any given market may be affected by specific market conditions and the strategies adopted by local operators.

Table 5: Estimated effect of MNP on real average retail prices, for countries with a five-day target maximum porting time

	Short run	*Long run*
Average prices (real revenue per minute)	–7.7 to –9.0%	–12.4 to –14.5%

Scope for future research

The mobile market data currently available on a consistent basis over time and across countries have limitations when used for modelling the effects of MNP. First, the choice of a five-day porting time threshold for examining MNP quality was dictated by the need to have an adequate sample of observations above and below the threshold. Future research into the effect of MNP will also benefit from the existence of additional time series data from jurisdictions where MNP has been implemented; many countries in the sample had only recently introduced these services. In addition, publication of harmonised cross-country data by supranational bodies such as CEPT, which published most of the MNP implementation and porting time data used in this study (see the Appendix), should make it easier for future researchers to make inter-country comparisons.

Secondly, it was not possible to control for the varying price of MNP across countries. In some jurisdictions, MNP is free to the subscriber, while in others it can involve significant fees. For example, the system adopted in Singapore in 1997 permitted operators to levy monthly charges on users, but from August 2003 onwards only a one-time administrative fee was allowed.[30] There is also variation in the level of one-off fees among those jurisdictions that permit them to be charged.[31] While charging could act as a deterrent to usage of MNP,[32] published information on such charges and on other aspects of MNP quality (for instance, whether or not it covers short messaging service (SMS) messages) is scanty, and these dimensions are not explicitly addressed in the analysis.

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APPENDIX

Additional information on the dataset

Table A1: Sample coverage and MNP data

Country	*Observations*	*MNP implemented ('–' if not implemented by 1Q 2006)*	*Target maximum porting time as of 1Q 2006 (days)*	*Main source for date of MNP implementation*
Argentina	27	–	–	
Australia	28	3Q01	0.0833	Regulator
Austria	6	4Q04	3	ECC/CEPT[33]
Brazil	14	–	–	Telegeography
Canada	25	–	–	Telegeography
Chile	5	–	–	MobileMonday
Denmark	16	3Q01	5	ECC/CEPT[33]
Egypt	6	–	–	Egypt Today
Finland	27	3Q03	5	ECC/CEPT[33]
France	28	3Q03	30	ECC/CEPT[33]
Germany	28	4Q02	6	ECC/CEPT[33]
Greece	20	3Q03	1	ECC/CEPT[33]
Hungary	8	2Q04	14	ECC/CEPT[33]
Ireland	6	3Q03	0.0833	ECC/CEPT[33]
Italy	28	2Q02	5	ECC/CEPT[33]
Japan	28	–	–	WirelessWatch
Malaysia	21	–	–	Frost & Sullivan
Mexico	24	–	–	Telegeography
Netherlands	10	2Q99	10	ECC/CEPT[33]
New Zealand	28	–	–	Regulator
Norway	28	4Q01	7	ECC/CEPT[33]
Philippines	5	–	–	Frost & Sullivan
Poland	16	4Q05	–	ECC/CEPT[33]
Portugal	28	1Q02	20	ECC/CEPT[33]
South Africa	28	–	–	Telegeography
Spain	4	4Q00	4	ECC/CEPT[33]
Sweden	28	3Q01	5	ECC/CEPT[33]
Taiwan	23	4Q04	–	Frost & Sullivan
Thailand	3	–	–	Telegeography
UK	27	1Q99	9	ECC/CEPT[33]