DID ASYMMETRIC MOBILE TERMINATION RATES HELP ENTRANTS GAIN MARKET SHARE?

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ABSTRACT
Regulators in many countries have asserted that setting asymmetric mobile termination rates (MTRs) between the incumbent mobile telephony operator and its smaller rivals is an efficacious means by which to help entrants attain efficient scale. We investigate empirically the efficacy of this policy experiment using data from a global sample of 34 countries from 1996 through 2014. We estimate a model that relates operators' long-run market shares to initial entry conditions and the degree of asymmetry among MTRs using an instrumental variables (IV) strategy. The estimates imply that a high degree of asymmetry among MTRs lowers an entrant's long-run market share by roughly 4 percentage points compared with a regime of symmetric MTRs, and the effect is roughly constant across market penetration levels. Furthermore, mobile operators tend to perform better when entering markets with higher levels of concentration and lower levels of market penetration. Our novel findings cast doubt on the efficacy of imposing asymmetric MTRs as a means to achieve greater equality of competitive outcomes. Our findings inform the larger body of theoretical literature on the pricing of interconnection and network access.

JEL: D43; K23; L13; L96

I. INTRODUCTION

When a mobile subscriber calls another person who subscribes to a competing mobile network, the receiving network typically charges the originating network operator an interconnection rate, called a mobile termination rate (MTR), to terminate the call on the receiving network. Although there exist different policies for MTRs, the majority of countries use the calling party network pays (CPNP) model in the wholesale market. By contrast, the United States, Canada, and Hong Kong rely on a system of bill and keep, whereby calls are terminated on a competing network without a financial settlement, which is equivalent to charging MTRs of zero. This arrangement is voluntary and not due to regulatory intervention. The pricing of network interconnection has drawn scrutiny from regulators around the world due to the allegation that market failure exists for terminating voice calls under CPNP, both in the fixed-to-mobile and mobile-to-mobile segments. According to a 2012 report by the Organisation for Economic Co-operation and Development (OECD), because every mobile operator supposedly has a monopoly over termination of calls on its own network, a mobile operator may set MTRs above its cost to extract rents from its competitors.[1] Because of this concern, regulators began setting MTRs based on cost models. For example, many countries, such as Germany and the United Kingdom, rely on a version of long-run incremental cost (LRIC) to set MTRs.

One of us has argued previously that it was unrealistic for regulators to set termination rates at marginal cost.[2] Competitive forces constrain an operator's market power in the pricing of termination rates, and exogenous price controls are unlikely to be socially optimal.[3] With regulated interconnection rates, certain questions emerged. If mobile operators have different cost structures, should they each be charging separate rates based on their respective cost structures? Should those rates depend on the stage of each operator's development? In light of such questions,

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[1] *See* Organisation for Economic Co-operation and Development (OECD), *Developments in Mobile Termination* 2 (OECD Digital Economy Papers, No. 193, Feb. 28, 2012), *available at* http://dx.doi.org/10.1787/5k9f97dxnd9r-en.

[2] Robert W. Crandall & J. Gregory Sidak, *Should Regulators Set Rates to Terminate Calls on Mobile Networks?*, 21 YALE J. ON REG. 261, 297 (2004).

[3] *Id.* at 287.

some regulators opted to impose *asymmetric* MTRs for incumbent or larger operators. Asymmetric MTRs mandated that those larger operators charge lower rates for terminating calls on their networks compared with the rates charged by smaller operators or entrants, with size measured by the share of subscribers within a country. Smaller operators or operators that had entered the market later thus received preferential rates. Other regulators in a number of countries have instead opted to impose symmetric MTRs, by which all operators charge the same MTRs.

A number of European countries adopted asymmetric MTRs with the primary justification being to assist entrants in competition with incumbents.[4] Regulators in these countries generally implemented asymmetric MTRs shortly following entry of a mobile operator in nations that previously had two or three operators. Although there has generally not been a consensus in approach across national regulatory authorities (NRAs), the European Commission issued guidelines in 2009 on the setting of MTRs. These guidelines reiterate the importance of symmetric rates based on cost models, with allowances for exogenous cost differences across carriers. They also grant asymmetric rates for new entrants for a transitional period of up to four years upon entry.[5] According to the Commission, roughly four years is an adequate period by which an entrant can achieve a minimum efficient scale, characterized by a market share of between 15 and 20 percent.[6] At the same time, in a number of other countries either MTRs were voluntarily symmetric or symmetry was a result of policy.

In light of the policy experiment of setting asymmetric MTRs, a natural question arises. To what extent have entrants under asymmetric MTRs performed better than entrants under symmetric MTRs? By assessing the global experience with asymmetric MTRs, we examine whether asymmetric MTR regulation has actually improved the market position of later entrants, relative to incumbents in the mobile telecommunications industry. To the best of our knowledge, this is the first empirical study of the impact of asymmetric MTR regulation on entrant performance on a retrospective basis. (By contrast, most studies examine the impact of asymmetric MTRs on mobile prices, as we discuss in Part II.) We use a sample of 38 mobile operators, most of which entered the market from 1998 through 2003, when the mobile industry was growing rapidly. Our main finding is that the impact of asymmetric MTRs on entrants' gain in market share has not been significant from either a statistical or an economic perspective.

In Part II, we review the arguments for and against asymmetric MTRs. In Part III, we evaluate the impact of asymmetric MTRs on the long-run competitive position of entrants. In Part IV, we provide perspectives on how the experience of MTR regulation in the mobile market may help shape future policy.

II. JUSTIFICATIONS FOR ASYMMETRIC MTRS IN THE ECONOMIC LITERATURE

The economic literature has emphasized rival theories about the effects of setting various levels of mobile termination rates on prices and competition. Although no consensus exists among policymakers about what the optimal termination rate might be, there seems to be a dominant view that regulating mobile termination rates is an important means of promoting competition in telephony. Because each network provider controls access to its own network, the argument is that mobile termination rates set by operators would necessarily be monopolistic and anticompetitive. According to the European Commission Recommendation, excessively high levels of termination rates are the main concern of regulatory authorities, and consequently mandating the cost orientation of interconnection access is the most appropriate policy intervention.[7] In this part, we provide an overview of the rival theories surrounding this policy issue.

[4] *See* European Commission (EC), Explanatory Note, Commission Staff Working Document, Accompanying the Commission Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU 5 (2009), *available at* http://ec.europa.eu/governance/impact/ia_carried_out/docs/ia_2009/sec_2009_0600_en.pdf.

[5] *See* European Commission (EC), Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU 69 (May 2009) [hereinafter EC Recommendation on MTRs], *available at* http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:124:0067:0074:EN:PDF.

[6] *Id.*

[7] EC Recommendation on MTRs, *supra* note 5, at 68.

A. The Cost-Disadvantage Justification

One justification given for implementing asymmetric MTRs is that it helps entrants reach sufficient scale to compete with the incumbent.[8] In an industry with high fixed costs and low marginal costs, even if all firms are equally efficient, the firm with the greatest market share will have the lowest average cost. The logic is that an entrant, which has not yet reached a sufficient level of scale to compete with incumbents, can earn greater revenue from charging a higher termination rate or can lower its costs by paying the incumbents a lower termination rate. The (often unstated) assumption is that the entrant will use the additional net cash flow to invest more quickly in increasing its scale. Under this justification, after an entrant has reached some threshold level of scale, the differential between its MTR and the incumbent's MTR should fall to zero. For example, the European Commission has recommended that a market share between 15 and 20 percent is sufficient for a wireless operator to reach minimum efficient scale.[9]

However, it is likely that asymmetric MTRs may have a detrimental effect on consumer welfare in the long run. Less efficient operators will have a reduced incentive to become efficient. It is generally recognized that price controls need to be related to the costs achievable by efficient firms, not to the costs actually incurred.[10] If asymmetric MTRs are set according to actual costs, a higher-cost firm has less incentive to reduce its costs. Any cost reduction will be partially offset by a loss in termination-rate revenue. In equilibrium, a firm that benefits from receiving a higher MTR based on actual costs will have less incentive to reduce costs and will have higher costs than a firm that benefits from asymmetric MTRs based on achievable costs. It may be the case that asymmetric MTRs actually increase costs within a market. Higher costs will lead to higher long-run equilibrium prices and reduced consumer surplus.

Regulators sometimes justify asymmetry in MTRs on the basis of exogenous cost differences between competing mobile operators, especially cost differences that arise from holding spectrum in different bandwidths.[11] For example, as frequencies increase, the area covered by a single cellular tower decreases. Therefore, it is cheaper to provide cellular coverage with lower bandwidths.[12] In those cases, asymmetric rates are typically based on an engineering cost model that purports to quantify the differences between the operators' actual costs. Thus, even though operators charge different fees, no operator necessarily has a cost disadvantage resulting from the different termination rates. However, a counterargument suggests that any higher costs due to higher-frequency spectrum allocation would have translated into a lower initial auction price for the spectrum. In other words, any increased expense of operating the network would have been compensated for in the form of a lower cost of acquiring the spectrum rights for the network. Therefore, the difference in the *total* cost of entry and providing service should be closer between high-frequency and low-frequency spectrum operators than the difference in operating costs between those operators.

B. The Network-Effects Justification

Another commonly presumed disadvantage that mobile entrants face is a barrier to entry in the form of network effects (sometimes called club effects). In markets characterized by network effects, a consumer's utility from consuming a particular good increases with the number of other consumers also consuming the good. The asserted barrier to entry arises when mobile operators charge differential prices depending on whether or not the call is terminated on the same network. In this case, consumers may be inclined to join the operator with the largest market share to

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[8] *See, e.g.*, Martin Peitz, *Asymmetric Regulation of Access and Price Discrimination in Telecommunications*, 28 J. REG. ECON. 327, 338 (2005).

[9] EC Recommendation on MTRs, *supra* note 5, at 69.

[10] *See, e.g.*, Tommasso Valletti, *Asymmetric Regulation of Mobile Termination Rates* 3 (mimeo) (Dec. 14, 2006), *available at* www.telepriser.no/ikbViewer/Content/100464/Vedlegg_Telenor.pdf.

[11] Value Partners, *Asymmetrical Pricing for Mobile Termination Charges* 2 (Dec. 2, 2008), *available at* http://s3.amazonaws.com/zanran_storage/www.coai.com/ContentPages/2500913789.pdf.

[12] *See, e.g.*, Yves R. Hamel et Associés Inc., *Analysis of the Coverage Differences Between the Cellular (850 MHz) and PCS (1900 MHz) Bands, Including a Sample Deployment Study of Highway 401 and Kingston, Ontario* (Mar. 13, 2003), *available at* http://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/microcellsch_e.pdf/$FILE/microcellsch_e.pdf.

maximize the number of calls made "on-net." Furthermore, some argue that a larger operator can foreclose competitors by charging an excessively high off-net price relative to its on-net prices.[13] This pricing differential supposedly discourages calls made to the smaller networks and thereby decreases the surplus that consumers receive from subscribing to the smaller operator.

The idea that network industries are prone to market failure requiring external intervention often proceeds from incorrect economic analysis.[14] Network effects can be exploited in small networks as easily as in large networks. An empirical study by Daniel Birke and Peter Swann found that a much stronger determinant of one's choice of network is not the overall existing number of its current subscribers, but the number of subscribers within one's own household or social network.[15] Birke and Swann found that adding roughly 9.2 million subscribers to a network would yield the same marginal benefit as if one additional member from one's household were to join the same network.[16]

A large body of theoretical literature has studied how network industries are prone to lock-in effects. A network can induce consumers to join by initially charging low prices and subsequently increasing prices. When switching costs are high, consumers are indifferent to joining a competing network even when lower prices are obtainable. This phenomenon may explain why an entrant into mobile communications can increase market share more easily by capturing a greater share of new subscribers than inducing switching from its competitors. (It would be interesting to test this hypothesis by examining the evolution of market shares of entrant operators, in terms of additional new subscribers versus subscribers gained from competitors, relative to penetration rates.) However, the practice of locking in consumers by offering initially low prices is a business strategy that an entrant operator is also likely to adopt, given that the value of any network increases with its size.

Finally, even if the theory that network effects serve as a barrier to entry were indisputable, the empirical record contains a number of examples of mobile operators successfully entering markets previously characterized by high levels of market concentration and few incumbent operators. For example, Vodafone entered in Hungary in 2000, when two incumbents dominated the market with roughly 50-percent market share each, and achieved a 20-percent market share within five years.[17]

C. The High-Market-Concentration Justification

Telecommunications industries typically have high levels of market concentration, a natural consequence of their cost structures. The move to promote entry through asymmetric MTRs in the mobile sector seems correlated with regulators' aversion to high levels of concentration. However, it has been argued previously that measures of market concentration will sometimes lead to incorrect conclusions about competition.[18] Although regulators historically have relied on static measures of market concentration to assess harm to consumers, there is an increasing trend to rely more on direct measures of consumer welfare, such as prices. For example, the Antitrust Division of the U.S. Department of Justice and the Federal Trade Commission updated the Horizontal Merger Guidelines in 2010 to emphasize direct evidence, such as prices, when assessing market

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[13] Ángel L. López & Patrick Rey, *Foreclosing Competition Through Access Charges and Price Discrimination* (Working Paper, June 2009), *available at* http://www.idei.fr/doc/wp/2009/foreclosing_competition.pdf.

[14] *See, e.g.*, DANIEL F. SPULBER & CHRISTOPHER S. YOO, NETWORKS IN TELECOMMUNICATIONS: ECONOMICS AND LAW 119 (Cambridge Univ. Press 2009).

[15] Daniel Birke & G.M. Peter Swann, *Network Effects and the Choice of Mobile Phone Operator*, 16 J. EVOLUTIONARY ECON. 65, 82–84 (2006).

[16] *Id.* at 81–82.

[17] BANK OF AMERICA MERRILL LYNCH GLOBAL WIRELESS MATRIX (unpaginated data set) (on file with authors) (2004–05, 2007, 2012, 2014). Also, Comcel (Claro) in Colombia overtook the incumbent by being an effective rival. *See* Letter from Hilda Maria Pardo Hasche, Alternate Legal Representative of Comunicación Celular S.A.—COMCEL S.A. to Christian Lizcano Ortiz, Executive Director, Communications Regulation Commission 12–13 (Nov. 4, 2011) (on file with authors).

[18] *See* Jerry A. Hausman & J. Gregory Sidak, *Evaluating Market Power Using Competitive Benchmark Prices Instead of the Herfindahl-Hirschman Index*, 74 ANTITRUST L.J. 387, 400–06 (2007).

power.[19] In the mobile industry specifically, the empirical evidence does not support the hypothesis that lower market concentration leads to increased consumer surplus.[20] As a result, it is not obvious that promoting entry benefits consumers (measured in terms of subscription prices).

There may even be a tradeoff between lowering market concentration through asymmetric MTRs and consumer welfare. Regulatory economists have hypothesized that implementing asymmetric MTRs—by lowering only the incumbent's rate—leads to higher mobile prices, a phenomenon called "the waterbed effect."[21] The waterbed effect describes the tendency for incumbents to raise retail prices in response to the lowering of the termination rates they can charge, leading to higher mobile prices. In other words, mobile network operators use termination rates to subsidize the cost of providing service to mobile subscribers. When regulators reduce the termination rates that an incumbent operator receives, the operator will typically increase the fixed portion of retail prices as a result. Aaron Schiff developed conditions whereby the waterbed effect occurs in industries with price regulation.[22] He specifically identified asymmetric MTRs as a likely example of the waterbed effect.[23] Mark Armstrong and Julian Wright have also suggested that a waterbed effect, though not necessarily a full effect, is present in mobile call termination.[24]

Empirical investigations of MTRs have found evidence of waterbed effects.[25] For example, Christos Genakos and Tommaso Valletti found that a 10-percent decrease in an incumbent's MTR results in an average retail price increase of 5 percent.[26] A 2012 empirical examination of individual network operators' termination rates and prices found a positive correlation between the degree of asymmetry in termination rates and network operators' average subscription prices.[27] Consequently, asymmetric MTRs may harm consumers through higher retail prices—irrespective of changes in market concentration.

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[19] *See* U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, HORIZONTAL MERGER GUIDELINES § 2.1.3 (Aug. 2010) ("Mergers that cause a significant increase in concentration and result in highly concentrated market power are presumed to be likely to enhance market power, but this presumption can be rebutted by persuasive evidence showing that the merger is unlikely to enhance market power.").

[20] *See* Hausman & Sidak, *supra* note 18, at 402.

[21] *See, e.g.*, Christos Genakos & Tommaso Valletti, *Testing the "Waterbed" Effect in Mobile Telephony*, 9 J. EUR. ECON. ASS'N 1114, 1115 (2011) (crediting Paul Geroski with coining the term); Aaron Schiff, *The "Waterbed" Effect and Price Regulation*, 7 REV. NETWORK ECON. 392 (2008); Mark Armstrong & Julian Wright, *Mobile Call Termination*, 119 ECON. J. F270, F284–86 (2009); Carlos M. Baigorri & Wilfred F. L. Maldonado, *Optimal Mobile Termination Rate: The Brazilian Mobile Market Case*, 38 TELECOMM. POL'Y 86 (2014).

[22] Schiff, *supra* note 21, at 404, 412–13.

[23] *Id.* at 393, 406–07.

[24] Armstrong & Wright, *supra* note 21, at F284–86.

[25] *See, e.g.*, Jongyong Lee & Duk Hee Lee, *Asymmetry of Mobile Termination Rates and the Waterbed Effect*, 23d European Regional Conference of the International Telecommunication Society (July 2012), *available at* http://hdl.handle.net/10419/60353.

[26] Genakos & Valletti, *supra* note 25, at 1116.

[27] Lee & Lee, *supra* note 25, 19.

III. AN EMPIRICAL ASSESSMENT OF THE IMPACT OF ASYMMETRIC MTRS ON ENTRANTS' LONG-RUN MARKET SHARES

Although the economic literature has provided theoretical predictions about the effects of asymmetric MTRs on competition,[28] we are unaware of any study that empirically assesses how entrants have fared under different MTR regimes. An empirical assessment of the success or failure of this policy is important for policymakers because the existing theory makes ambiguous predictions. Our findings may therefore inform and improve future regulation. Our empirical approach estimates the effects of asymmetric MTRs on entrant performance with all the available data while imposing minimal assumptions about the structure of the data.[29]

A. The Data

Our estimation sample contains data on 34 mobile operators that entered their respective markets from their year of entry until 2014. We selected all mobile operators included in available data sources that launched during the same five-year time period between 1998 and 2003. This period roughly coincided with the rapid development of the mobile industry when mobile phones proliferated among consumers. Worldwide, the mobile penetration rate increased from 5.35 subscriptions per 100 residents in 1998 to 22.32 subscriptions per 100 residents in 2003.[30] Within the OECD, mobile penetration increased from 22.04 subscriptions per 100 residents in 1998 to 64.76 subscriptions per 100 residents in 2003.[31] Table 1 lists the operators in our study, the year of entry, and the year in which asymmetric MTR regulation was enacted in the country in which it operated, and the year in which MTRs in the country became symmetric.

Table 1. Entrants in countries with asymmetric MTRs

Country	Entrant	Year entered	Year implemented	Year symmetry achieved
Austria	tele.ring	2000Q4	2003	2009
Austria	Drei	2003Q4	2003	2009
Belgium	Base	1999Q3	2001	2013
Denmark	3 (Hutchison)	2003Q4	2004	2012
Finland	Telia (DNA)	1999Q1	2003	2009
Germany	O2 Germany	1999Q1	1998	2013
Hungary	Vodafone	2000Q4	2002	2009
Ireland	Meteor	2001Q1	2002	2013
Italy	Wind	1999Q1	2005	2012
Italy	3 (Hutchison)	2003Q2	2005	2012
Netherlands	O2 Netherlands	1999Q1	1999	2011
Netherlands	Ben (T-Mobile)	1999Q1	1999	2011
Netherlands	Dutchtone (Orange)	1999Q1	1999	2011
Switzerland	Orange	1999Q4	2000	2013
Switzerland	Sunrise	1998Q4	2000	2013
United Kingdom	3 (Hutchison)	2003Q1	1999	2011

Note: We observe entrants for 9.36 years on average.
Source: BANK OF AMERICA MERRILL LYNCH GLOBAL WIRELESS MATRIX, *supra* note 17.

[28] *See, e.g.*, Genakos & Valletti, *supra* note 21; Jean-Jacques Laffont, Patrick Rey & Jean Tirole, *Network Competition: II. Price Discrimination*, 29 RAND J. ECON. 38, (1998); Sjaak Hurkens & Doh-Shin Jeon, *Promoting Network Competition by Regulating Termination Charges*, 30 INT'L J. INDUS. ORG. 541 (2012).
[29] *See, e.g.*, CHARLES MANSKI, IDENTIFICATION FOR PREDICTION AND DECISION 3 (Harvard Univ. Press 2007).
[30] WORLD BANK, WORLD DEVELOPMENT INDICATORS (2012), *available at* http://data.worldbank.org/data-catalog/world-development-indicators.
[31] *Id.*

Table 2 lists the operators that entered under a regime of symmetric MTRs that form our control group. On average, we observe entrants over a nine-year period. Our data set includes information on (1) market penetration (the percentage of the population that has a mobile telephone), (2) the evolution of entrants' market shares (based on the number of subscribers), (3) the Herfindahl-Hirschman Index (HHI) (a nonlinear measure of market concentration), and (4) mobile termination rates.[32] The data are quarterly.

Table 2. Entrants in countries with symmetric MTRs

Country	**Entrant**	**Year entered**
Australia	Hutchison	2000Q2
Austria	Connect	1998Q4
Brazil	Oi (Tele Norte Leste)	2002Q3
Chile	Smartcom (Endesa)	2000Q4
Columbia	Colombia Movil	2003Q4
Czech Republic	Oskar	2000Q4
Denmark	Orange	1998Q2
Hong Kong	Sunday	1998Q1
Hong Kong	Peoples	1997Q1
Israel	MIRS	1999Q4
Israel	Partner	1999Q1
Philippines	Digitel	2004Q1
Portugal	Optimus	1998Q4
Singapore	Starhub	2000Q3
South Africa	Cell C	2001Q4
Spain	Amena	1999Q1
Sweden	3 (Hutchison)	2003Q2
Turkey	Is Tim / (Avea)	2001Q1

Note: We observe entrants for 9.40 years on average.
Source: BANK OF AMERICA MERRILL LYNCH GLOBAL WIRELESS MATRIX, *supra* note 17.

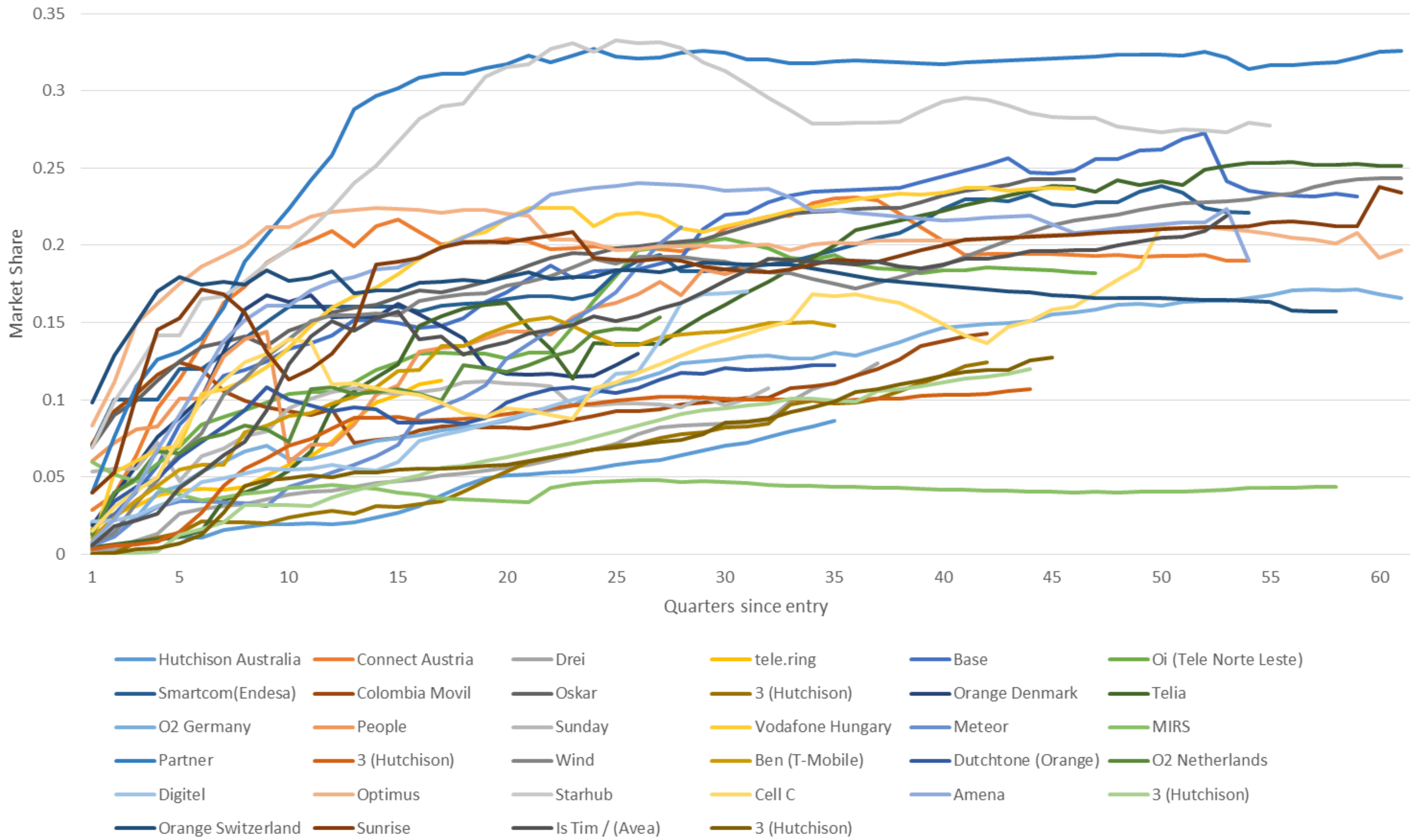
Figure 1 shows how the market share for each entrant evolved over time, beginning with the time of entry. A typical pattern emerges in which the average operator's market share increases rapidly upon entering and eventually reaches a long-run level, at which point the growth rate decreases and market share remains relatively stable.[33] We do not observe each entrant for the same length of time because not all entrants entered during the same year. Furthermore, so as to avoid endogenous changes in market share, we stop observing an entrant when it merges or is acquired by a competing firm.

Figure 2 shows the level of asymmetry of MTRs for selected operators for the period from 2003 to 2014. We measure the level of asymmetry as the ratio of termination rates between the entrant and the incumbent. The data indicate that the level of asymmetry has been generally declining and, in several countries, symmetry has been obtained (or in some cases is expected to be obtained by 2015).

[32] The HHI is used as a measure of market concentration. It is calculated by summing the squares of the market shares of each firm in a market. For example, in an industry where one firm has 70% of the market and another firm has the remaining 30%, the HHI will equal 5800. Possible values for the HHI range from 0 (perfect competition) to 10,000 (monopoly).

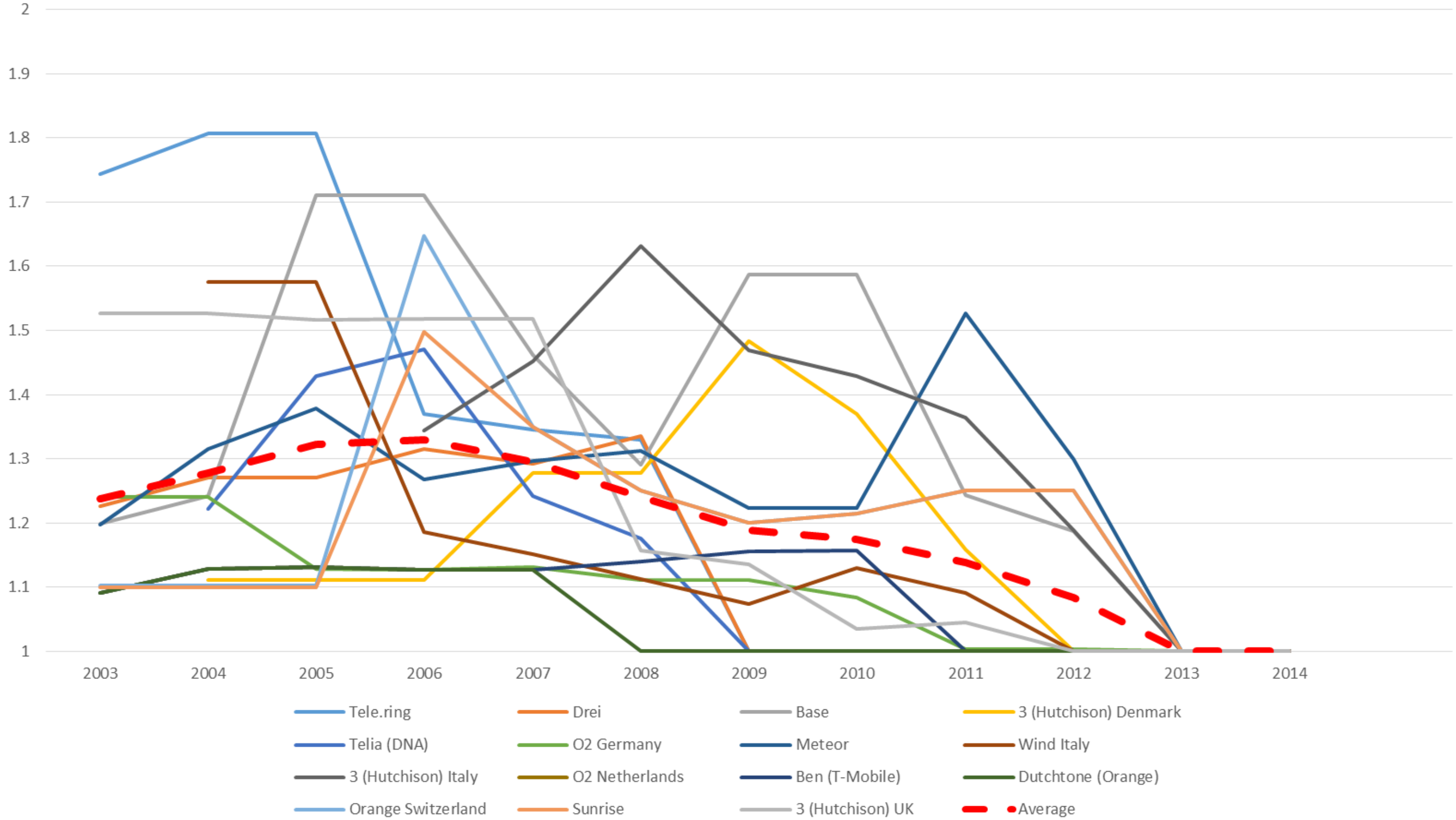
[33] A similar finding is obtained by Govert E. Bijwaard, Maarten C.W. Janssen & Emiel Maasland, *Early Mover Advantages: An Empirical Analysis of European Mobile Phone Markets*, 32 TELECOMM. POL'Y 246 (2008).

Figure 1. Development of market shares from time of entry



Source: BANK OF AMERICA MERRILL LYNCH GLOBAL WIRELESS MATRIX REPORTS, *supra* note 17.

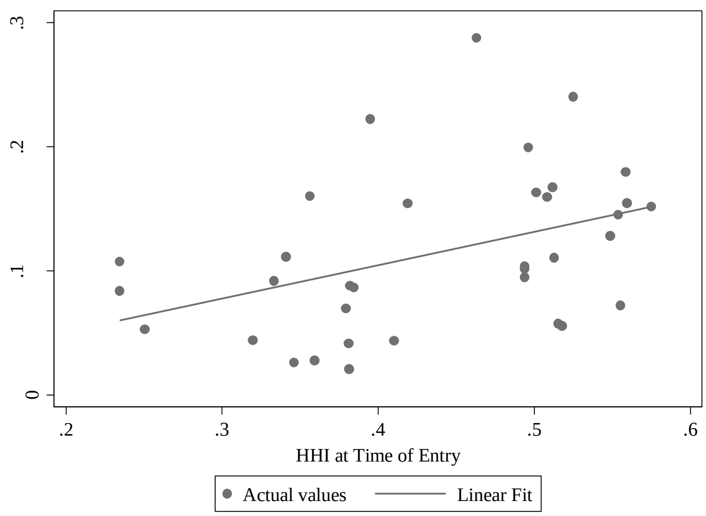
Figure 2. The level of asymmetric MTRs for selected operators



Note: The *y*-axis shows the ratio of MTRs for the entrant relative to the incumbent with the greatest market share.
Source: OVUM TELECOM RESEARCH, INTERCONNECT CHARGE DATA.

Figure 3 shows the relationship between market concentration at time of entry and subsequent entrant performance three years post-entry. Interestingly, entrants in industries with higher concentrations tend to perform better in terms of gains in market share than do entrants in industries that appear more competitive. One explanation for this direct relationship between pre-entry concentration and entrant performance is that, all else equal, the fewer firms that are competing in a market before entry, the higher the HHI will be. Again, holding all else equal, in these countries, the entrant will compete against fewer firms. At the same time, the result that entrants grow faster in more concentrated markets suggests that network effects may not be a significant barrier to growth in the mobile industry. In more concentrated markets, incentives for subscribers to purchase from an incumbent with a high market share are greater than in less concentrated markets, based on network effects. Better performance by entrants in concentrated markets suggests that firm-specific network effects are not strong in the mobile industry.

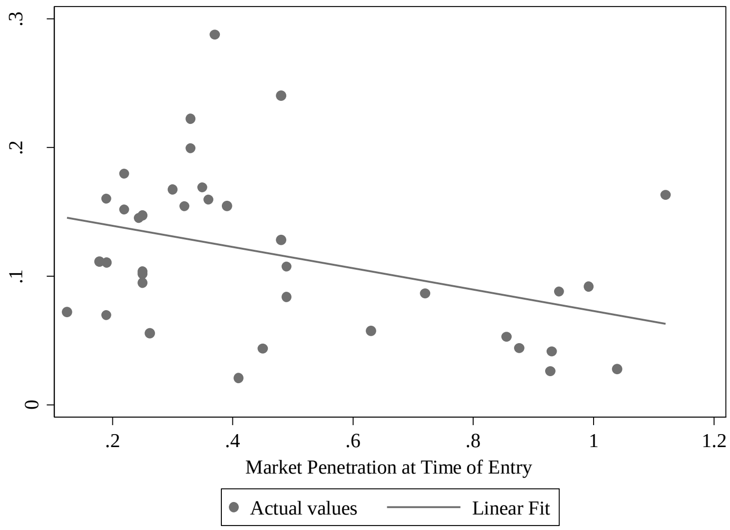
Figure 3. The relationship between HHI at the time of entry and entrant performance three years after entry



Source: BANK OF AMERICA MERRILL LYNCH GLOBAL WIRELESS MATRIX, *supra* note 17.

Figure 4 shows a negative relationship between entrant performance and market penetration at the time of entry. This result is consistent with the proposition that, when industries are in a rapid state of development, entrants can more easily gain market share by acquiring subscribers from new adopters as opposed to attracting existing customers from competitors.

Figure 4. The relationship between market penetration at time of entry and entrant performance three years following entry



Source: BANK OF AMERICA MERRILL LYNCH GLOBAL WIRELESS MATRIX, *supra* note 17.

B. Empirical Strategy

Our empirical analysis attempts to explain the evolution of market shares of entrant mobile operators over time while capturing the non-linear dynamics presented in Figure 1. Bijwaard, Janssen, and Maasland employ the following specification for a firm's market share:

$$m_{it} = \gamma_i \, (1 - e^{-\beta it}), \quad (1)$$

where m_{it} is the market share of firm *i*, *t* is the number of months after entry, γ_i represents the *i*th firm's long-run market share level, and β_{it} represents the speed of convergence, which is the rate at which the firm's market share approaches its long-run market share.[34] This equation models the firm's market share in the current period as a function of the long-run level and the speed of convergence. Over time, the firm's market share approaches its long-run level but at an increasingly slower rate as $e^{-\beta it}$ approaches zero. The long-run market share is modeled as a function of exogenous, time-invariant factors that characterize the mobile industry when entry occurred. In contrast, the speed of convergence at each period of time is modeled as a function of current period factors. For example, one can specify the following functional form for γ_i:

$$\gamma_i = e^{\,\alpha 1 pen i + \alpha 2 HHI i}, \quad (2)$$

where the exponential ensures that the market share is positive.[35] *Pen* and *HHI* represent market penetration and market concentration just before the *i*th firm's entry. This strategy treats variables characterizing the mobile industry just before an operator's entry as exogenous factors that explain subsequent entry performance, conditional on the entry decision.[36] Because they do not depend on

[34] *Id.* at 251; *see also* Gurumurthy Kalyanaram & Glen L. Urban, *Dynamic Effects of the Order of Entry on Market Share, Trial Penetration, and Repeat Purchases for Frequently Purchased Consumer Goods*, 11 MARKETING SCI. 235 (1992).

[35] In practice, the true long-run market share level is unknown, but we use the last-observed market share observation as an approximation. As a robustness check, in a separate estimation we treat the long-run market share as the firm's market share five years after entry.

[36] Simultaneity bias and lack of available Hausman instruments prevents us from incorporating time-varying regressors in the model. For example, modeling survival data using the Cox semi-parametric specification typically relies on only initial conditions as explanatory variables.

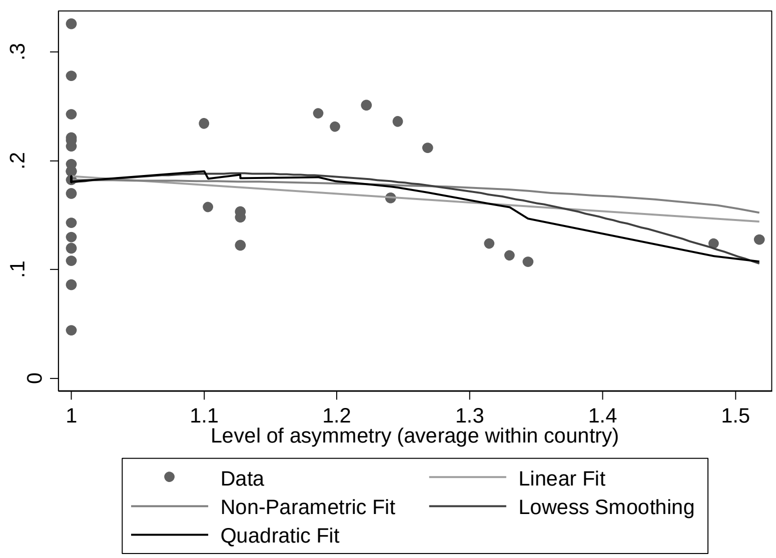
the evolution of market shares, these variables are by construction exogenous. Equation 2 provides a rationale for estimating a reduced form equation of market shares on the available explanatory variables. For the purpose of our study, we are interested in explaining merely the long-run levels of market share and not the dynamics or speed of convergence.

For our econometric analysis, we transform equation 2 into its logarithmic form and add factors that affect entrant performance:

$$y_i = \alpha_1 peni + \alpha_2 HHIi + \alpha_3 Asy_i\,. \tag{3}$$

In this augmented model, Asy_i measures the degree of asymmetry of the entrant's MTR regime, where the degree of asymmetry is defined as the ratio of termination rates between the incumbent operator and the entrant. In our benchmark approach, we obtain estimates for the coefficients in (3) by relating the dependent variable to observables by OLS. Figure 5 depicts a negative relationship between entrant performance and the degree of asymmetric MTRs under which entrants operated. However, without a structural model, the estimated effect cannot be interpreted as causal.

Figure 5. The relationship between the level of asymmetry and long-run entrant performance



Sources: BANK OF AMERICA MERRILL LYNCH GLOBAL WIRELESS MATRIX *supra* note 17; OVUM TELECOM RESEARCH, INTERCONNECT CHARGE DATA.

An important consideration is whether the regulator's decision to implement asymmetric MTRs is exogenous with respect to the performance of mobile entrants. A selection bias might arise if regulators were *more* likely to implement asymmetric regulation when entrants were also likely to perform poorly because of unobserved factors. Under this assumption, the treatment group is no longer a random group of entrants and is systematically different from the control group. In this case, an empirical assessment of the policy under study might confound its true impact with differences between the two samples that are due to factors unrelated to the policy. When unobserved variables drive these differences, causal inference becomes problematic—a condition sometimes called the problem of unobserved heterogeneity or omitted-variable bias.[37] One solution is to estimate a two-system equation that models separately the regulator's decision

[37] WILLIAM H. GREENE, ECONOMETRIC ANALYSIS 148 (Prentice Hall, 5th ed. 2003).

to adopt asymmetric regulation.[38] Use of valid exclusion restrictions or Hausman instrumental variables (IVs) aids this approach. The IVs in this case are factors that would explain the regulator's decision to adopt asymmetric MTRs but that would also be unrelated to the outcome variable of interest—namely, an entrant's long-term market share. Without valid IVs, identification depends on strong assumptions that require the error terms to follow a bivariate normal distribution as well as appropriate functional forms.[39]

To obtain a more structural interpretation of our econometric results, we adopt this framework and use a novel instrumental variable that accounts for the type of MTR regime but that is unrelated to an entrant's performance. Our first-stage equation includes the entrant operator's country HHI and penetration rate as well as an indicator variable whether the entrant's country is part of the European Union (EU) or not. The policy of asymmetric mobile termination rates originated in Europe and became a popular initiative. Given the geographic distribution of symmetric and asymmetric termination rates, there will be a strong correlation between adoption of an MTR regime and EU membership. However, EU membership should be uncorrelated with entrant performance, as the entrants within the European Union entered into a variety of market structures with widely varying results.

C. Results

Table 4 reports coefficient estimates for the first-stage equation, the model based on OLS, and the model based on instrumental variables. The first-stage results find that higher levels of market penetration and whether the entrant operates in an EU member country lead to higher levels of asymmetric MTRs. The model is jointly statistically significant, and our instrumental variable passes the weak IV test.

Table 3. Regressions of asymmetric MTRs on entrant long-run market share and other variables

	OLS	**First Stage**	**IV**
HHI	0.152***	–0.054	0.165***
	(0.06)	(0.11)	(0.06)
Market Penetration	–0.049	0.226**	–0.018
	(0.04)	(0.11)	(0.08)
EU		0.125***	
		(0.03)	
Asymmetric MTR level	–0.009		–0.098
	(0.09)		(0.21)
Constant	0.130***	–0.05	0.118***
	(0.03)	(0.07)	(0.03)
N	34	34	34
R^2	0.22	0.55	0.20

Note: Robust standard errors displayed in parentheses. *** Indicates significance at 1%, ** at 5%, and * at 10%. Dependent variable in the first-stage regression is the asymmetric MTR level. The dependent variable in the OLS and IV regressions is the entrant long-run market share.

In the OLS results, the effect of HHI is highly statistically significant with the expected sign. A 10-percentage-point increase in HHI is associated with an increase of 1.52 percent in the entrant's long-run market share. In contrast, conventional wisdom would have predicted that

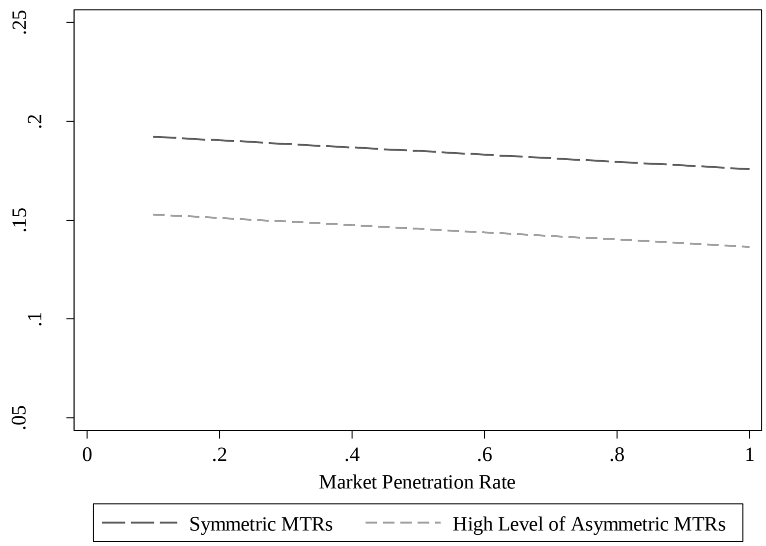
38 James Heckman, *Dummy Endogenous Variables in Simultaneous Equations System*, 46 ECONOMETRICA 931, 931 (1978).

39 Panel data methods are another way to account for unobserved heterogeneity. *See, e.g.*, CHENG HSIAO, ANALYSIS OF PANEL DATA 314 (Cambridge Univ. Press 2d ed. 2003). Hsiao discusses how either to parameterize the unobserved heterogeneity using the random-effects approach or to difference it through the fixed-effects approach. *Id.*

entrants in markets with high levels of market concentration would have obtained lower market shares, all other factors held constant. Interestingly, the effect of market penetration is not statistically significant, although the sign is, as expected, negative. Our estimates are qualitatively consistent with those found by Bijwaard, Janssen, and Maasland using a data set of only European countries from the early 1990s until 2006.[40]

The estimated effect of the asymmetric MTR level is –0.009 under OLS but increases in magnitude to –0.098 under IV. In contrast, the estimates for the exogenous explanatory variables are little changed between OLS and IV. In both specifications, the effect of asymmetric MTRs is not statistically significant and, as expected, the standard error increases under IV due to its estimation procedure and small sample. However, we can interpret the economic significance of the IV estimate as a ten-percent shift in the level of asymmetry, causing a 0.98-percent decrease in the entrant's long-run entrant market share. Figure 6 simulates the effect of changes in initial market penetration on long-run market share under the scenario of symmetric MTRs compared with a high level of asymmetric MTRs. The model predicts that the long-run market share decreases with penetration, but a four-percentage shift occurs between MTR regimes.

Figure 6. The impact of high asymmetric MTRs on long-run entrant market share



Note: The predictions are based from the IV model, holding HHI at its mean level.

Our IV estimation mitigates any selection bias that might affect our analysis. However, a regulator's decision to implement asymmetric MTRs is a methodological process that relies on an analysis of the industry setting, such as market concentration; that decision does not depend on the extent to which an entrant is likely to perform poorly. Furthermore, because asymmetric MTRs were implemented generally within a few years of entry, a regulator would not have enough data points to make reasonable inferences about the likely future performance of entrants, especially given the changes in market share, which are highly nonlinear in the firm's first few years of operation.

Our analysis inherently assumes that the entry decision of recent operators is exogenous. In theory, one could imagine that operators may condition their entry decisions on the likelihood that a regulator will impose asymmetric termination rates in the future. However, given that regulators typically implemented asymmetric MTRs a few years after entry, we believe that a reverse causal mechanism does not exist. Our results can be interpreted as conditional on the entry decision of

[40] Bijwaard, Janssen & Maasland, *supra* note 33, at 255.

operators. We do not assess whether the adoption of asymmetric MTRs increases the probability of entry.

IV. POLICY IMPLICATIONS

Our empirical findings reveal that entrant performance under regulatory regimes of asymmetric MTRs fared no better than under symmetric MTRs. This result is not surprising. Economic theory suggests a number of reasons why MTR regulation would not achieve its intended goal of assisting entrants' competitive market positions. The asymmetry in rates distorts competition and competitors' incentives. For example, a rival firm has a reduced incentive to increase the size of its network and its subscribership if, by doing so, it would end up being compelled to charge a lower, asymmetric MTR. Similarly, when an operator can receive a higher MTR because it has higher costs, it has less incentive to invest in measures that would reduce its costs and therefore its prices. As a consequence of those perverse incentives, under asymmetric MTRs competition becomes muted and prices rise—or fall more slowly than they would in a regime of symmetric MTRs. The concern over market power in call termination applies equally to all firms, irrespective of size. By requiring efficient operators to subsidize the relative inefficiency of their competitors, an unintended long-term consequence of asymmetric MTRs may be to reduce telecommunications investment in improved efficiency.

Our empirical assessment of the impact of asymmetric MTRs on entrants' market shares, combined with the evidence that asymmetric rates lead to higher mobile prices for consumers, suggests that this policy experiment has not only failed to achieve its goals, but that it has also reduced consumer welfare. As Tommasso Valletti has argued, confusion seems to exist with respect to the frequently cited goals of regulators: constraining market power and promoting competition.[41] Attempting to achieve the former does not necessarily achieve the latter. The finding of significant market power in one market does not validate regulatory intervention in other segments of an industry without a careful examination of the benefits and costs of that intervention. No economic theory teaches that promoting competition should entail protecting small firms. In fact, the most competitive industries are characterized by high rates of failure of entrant firms, or high turnover.

Asymmetric MTR policies attempt to reduce market concentration. They do not specifically address consumer welfare. Implicit in the argument supporting asymmetric MTRs is the conjecture that, if a market is less concentrated, in the long run, prices will be lower than they are in a more concentrated market, and consumers will thus benefit. Essentially, asymmetric MTR policies are designed to promote welfare in the long run, even if they induce short-run consumer welfare loss through higher retail prices.

This approach has two key weaknesses. First, it is based on the assumption that a less concentrated market will necessarily be more competitive in the long run. Past analysis has cast doubt upon the hypothesis of a relationship between market concentration and competition in mobile markets.[42] In fact, our empirical analysis rejects this hypothesis. Second, asymmetric MTRs may have an effect on entrant efficiency in the short run. In addition to any waterbed effect, higher costs would lead to higher retail prices. The long-run analysis would assume that costs converge to their long-run levels after symmetry of MTRs is imposed. But any inefficiencies generated by asymmetric MTRs would increase the time it takes to arrive at long-run equilibrium. Both the entrant and consumers would fare worse in the interim.

Unfortunately for proponents of asymmetric MTRs, this tradeoff between long-run and short-run welfare never occurs. Our analysis suggests that entrants' long-run market shares attain levels just as high in countries with symmetric MTRs as in countries with asymmetric MTRs. Consequently, if asymmetric rates lead to higher consumer prices in the short run and there is no long-run difference in market structure, then the welfare outcome of asymmetric MTRs is unambiguously negative. Even if there is no short-run price effect and the welfare outcome is

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[41] Valletti, *supra* note 10, at 2.

[42] *See, e.g.*, Hausman & Sidak, *supra* note 18.

neutral, entrants still have a reduced incentive to become more efficient. Regardless of whether the price effect exists, there is no empirical support for the success of asymmetric MTRs.

Our empirical analysis focused on the use of asymmetric MTRs during a period when the mobile telephone industry was growing rapidly and operators were adding new subscribers across the world. In 2011, mobile penetration was 114.11 mobile subscriptions per 100 residents in the OECD countries and 85.55 mobile subscriptions per 100 residents in the world.[43] During the years examined, it may have been easier for an entrant to grow than it is in 2015. An entrant may have been able to grow by capturing a high percentage of new subscribers without attracting subscribers away from incumbent operators. Thus, critics of our approach may assert that, although asymmetric MTRs did not aid in the growth of entrants during the years of our study, asymmetric MTRs are necessary to ensure the growth of entrants today. However, our model simulation analysis conducted in Figure 6 directly rejects this assertion. The estimated effect of asymmetric MTRs was negative for a range of mobile penetration rates. Although mobile penetration rates affect the growth of new entrants, they do not affect the effectiveness of asymmetric MTRs. Therefore, asymmetric MTRs are no more likely to be effective in the future than they have been in the past.

V. CONCLUSION

Most economic literature on regulation focuses on the welfare effects of pursuing a stated regulatory objective. It is rarer for economic research to assess the efficacy of the means employed to achieve a stated regulatory objective, and rarer still for economic research to evaluate whether experience can confirm empirically that the chosen regulatory instrument was indeed efficacious in achieving the stated regulatory objective.

Regulators of various countries have asserted that setting asymmetric mobile termination rates between the incumbent mobile telephony operator and its smaller rivals is an efficacious means by which to help entrants attain efficient scale. Having examined the effect of asymmetric MTRs on long-run market shares of 34 mobile entrants from 1998 to 2014, we find that, on average, mobile entrants fared as well under a regime of symmetric MTRs as under a regime of asymmetric MTRs. We do not find any positive effect from mandating asymmetric MTRs. Although fears about lack of competition arise when there is high market concentration, the data suggest that this condition favors entrants. Mobile operators tend to perform better when entering markets with higher levels of concentration.

Our findings shed light on the efficacy of regulating MTRs as a means to achieve greater equality of competitive outcomes, as well as the larger body of theoretical literature on the pricing of interconnection and network access. Our findings call into question the common assumption that the presence of an incumbent mobile operator with a dominant market share forecloses competition and that interconnection among mobile operators consequently suffers from market failure.

Asymmetric MTRs v23.doc December 1, 2015 12:00 p.m. EST

[43] WORLD BANK, *supra* note 30.