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## Conference Paper

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23rd European Regional Conference of the International Telecommunication Society,  
Vienna, Austria, 1-4 July 2012

## Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Kongaut, Chatchai; Bohlin, Erik (2012) : Impacts of mobile termination rates (MTRs) on retail prices: The implication for regulators, 23rd European Regional Conference of the International Telecommunication Society, Vienna, Austria, 1-4 July 2012

This Version is available at:

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# Impacts of Mobile Termination Rates (MTRs) on Retail Prices: The Implication for Regulators

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## Abstract

Mobile termination rates (MTRs) have been an important issue for regulators and operators in the telecommunications industry. Most regulators, especially the European Commission (EC), have tried to cut MTRs using cost-based regulation in the belief of improving social welfare and encouraging an efficient market. The operators, however, have disagreed and argued that decreasing MTRs can substantially reduce consumer welfare. There is also only a limited number of empirical analyses on the impacts of MTRs. In the new set of up-to-date data from 2006-2011, many countries have continuously reduced their MTRs. This paper therefore aims to enrich the empirical analysis of the impacts of MTRs on retail prices.

This paper applies the one-step generalised method of moments (GMM) approach to dynamic panel data. The results support the hypothesis that lower MTRs will reduce consumer retail prices, which is consistent with the EC framework. It is therefore recommended that regulators in the calling party network pays (CPNP) regime reduce MTRs to at least the same level as the operators' cost to raise overall social welfare, especially consumer welfare. However, the approach by each country can differ depending on its situation.

**Keywords:** mobile termination, regulation, retail prices

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## 1. Introduction

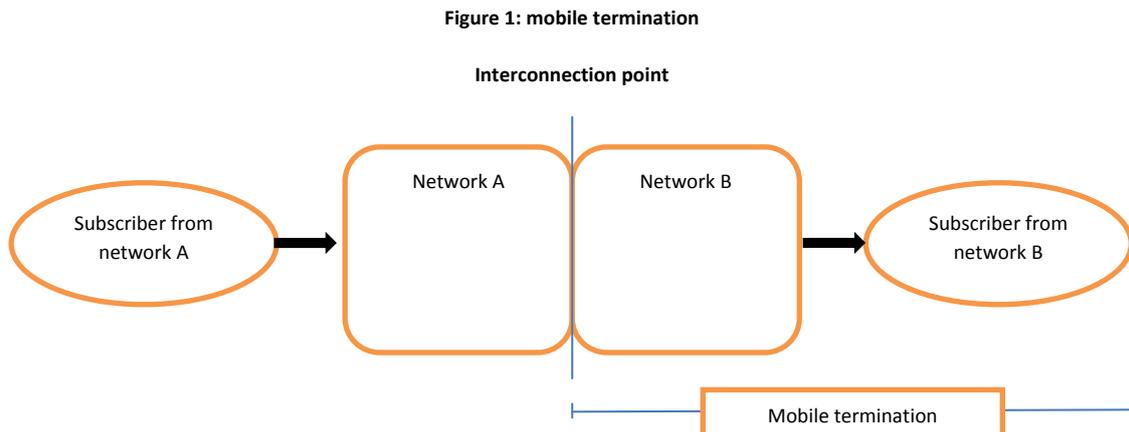
Despite massive growth and greater competition, the mobile industry needs to be regulated. One of the reasons is its unique characteristic, namely mobile call termination. Each mobile operator is considered a monopolist for its own termination call. Most countries, especially those in the European Commission (EC), are therefore concerned about this issue and have established a regulatory framework for mobile termination rates (MTRs).

MTRs have been an important issue for regulators and operators in the telecommunications industry. Most regulators, especially the EC, have tried to cut MTRs using cost-based regulation, primarily the long-run incremental cost (LRIC) model, in the belief of improving social welfare and encouraging an efficient market. The operators, however, have disagreed and argued that decreasing MTRs can substantially reduce consumer welfare (Frontier Economics 2008). There have been arguments and comments on the best way to regulate MTRs from operators and regulators from all the member countries, especially after the EC released the draft Commission recommendation on the regulatory treatment of fixed and mobile termination rates in the EU in 2008. Moreover, the arguments are not only between the regulators and mobile operators, there have also been several discussions and debates from academic researchers in the past decade. The debate has been extensively argued from many aspects, for example, whether MTRs below cost or above cost would provide higher social welfare, whether cost-based regulation or bill and keep would encourage greater benefits for consumers, whether lower MTRs would increase or decrease the retail price, etc. In the past decade, theoretical literature, such as Armstrong (1998), Berger (2005), Hurkens and López (2010), etc. has analysed the MTRs or interconnection that have been developed from 1998 until now. However, there is only a limited number of empirical analyses on the impacts of MTRs. In the new set of up-to-date data from 2006-2011, many countries have continuously reduced their MTRs. This paper therefore aims to enrich the empirical analysis of the impacts of MTRs on retail prices.

This paper consists of eight sections with the following structure. This first section introduces the recent debate on MTRs, including the aims of this paper. The second section describes the concept of mobile termination and the charging regimes. The third section provides a literature review on the impacts of MTRs, both theoretical and empirical studies, though, the review focuses on empirical evidence. In the fourth section, two main theories, the two-sided market and the waterbed effect, are used to explain the impacts of MTRs. The fifth section describes the methodology, econometric model specification, data and limitations. The sixth section shows a graphical and statistical analysis of MTRs. The seventh section the empirical results are presented and discussed. The results are also compared with previous studies. Finally, the last section concludes the paper and suggests an implication for regulators and the trend of future research.

## 2. Mobile Termination and Charging Regimes

This section describes the general concept of interconnection and mobile termination. Mobile termination charging regimes are also briefly explained. An explanation of interconnection and mobile termination is presented in Figure 1. Providing a subscriber from one network calls a subscriber from another network, the interconnection point to the other subscriber can be seen as the mobile call termination. The mobile termination rate is considered a wholesale charge for interconnection.



From Figure 1, network A is generally responsible for its own originating cost up to the interconnection point. From the interconnection point to the subscriber from network B, which is referred to as mobile termination, the network that is responsible for the cost differs depending on the charging regime. For example, in the EU, a calling party network pays (CPNP) regime applies: the originating operators have to pay this cost to network B. In Singapore, on the other hand, the bill and keep (BAK) regime applies: the terminating operators in Singapore are responsible for this cost in their own networks. According to the OECD (2012), the charging regimes for wholesale interconnection can be categorised into four models:

1. Calling party network pays (CPNP) – The originating network is responsible for its origination cost and pays the termination cost to the terminating network. The payments to the terminating network are known as MTRs. The CPNP regime is used by most countries including the EU.
2. Receiving party network pays (RPNP) – The terminating network is responsible for the terminating cost and also has to pay the originating network for the originating cost. This model does not exist in any country.
3. Bill and keep (BAK) or Sender keeps all (SKA) – The originating network is responsible for its origination cost and the terminating network is responsible for the terminating cost. Singapore and Hong Kong apply this model while the USA combines the BAK and CPNP models for its charging regime.

4. Peering and transit – This model is mostly applied to Internet interconnection and is usually referred to as a BAK model though it is slightly different in practice.

The OECD (2012) also claimed that the literature sometimes mixed the use of the wholesale charging regime with the retail charging regime. The OECD (2012) therefore said that the retail regimes could be divided into three categories as follow:

1. Calling party pays (CPP) – The caller is responsible for the cost of communication while the receiver does not pay any cost. CPP is used by most countries and is usually combined with the CPNP model. However, CPP can be mixed with other wholesale regimes. For example, Singapore applies BAK but uses CPP as a retail charging regime.

2. Receiving party pays (RPP) – The OECD (2012) mentioned that, strictly defined, this model can be considered as the receiving party being responsible for the cost of communication while the caller does not have to pay. For example, the USA, in which both the caller and the receiver have to pay, should be considered as combining two regimes, a mix of CPP and RPP. The OECD (2012) accurately claimed that the USA's retail regime would be better categorised as a bundled regime.

3. Bundled – There are several approaches to bundling voice service, such as bundling with SMS, MMS or even a mobile phone.

Nevertheless, the main focus of this paper is on the impact of lower MTRs on the retail price in Europe by the EC. All the countries concerned in this paper apply CPNP as a wholesale regime. The wholesale interconnection cost for mobile termination in this paper is therefore referred to as the MTR, which the originating operator needs to pay to the terminating operator. Similarly, the retail price in this paper is also referred to as the price that the caller needs to pay for the communication while the receiver does not pay at all.

### **3. Literature Review**

The early stage of the literature on MTRs started in approximately 1998 as a form of either interconnection or an access price issue. MTRs can be categorised into two types: fixed-to-mobile termination rates (FTM) and mobile-to-mobile termination rates (MTM). They had not been mentioned separately at this early stage however. Armstrong (1998) extended his previous analysis of one-way access pricing to mutual two-way interconnection by applying a model of a competing network. The assumptions from Armstrong (1998)'s paper included the linear and non-discriminated retail pricing, a symmetric model without regulation, an asymmetric model with regulation, etc. The paper concluded that networks in the symmetric assumption prefer to set a high interconnection charge for collusion. The interconnection charges, which optimise social welfare, should therefore be set below a marginal cost, and the regulator should, at least, monitor the market. Along with Armstrong (1998), at that time, Laffont et al. (1998a, b) and Carter and Wright (1999) also produced some studies in a similar style to that of Armstrong (1998) but relaxing more assumptions. Since then, the

literature has been developed in several aspects, for example, the studies towards the asymmetric networks assumption, the debate between the use of cost-based regulation and the BAK debate (this paper only focuses on the CPNP regime however) and, currently, the waterbed effect<sup>2</sup> debate, which also raises growing empirical evidence on the impacts of MTRs.

There has been little previous empirical evidence relating to MTRs. For instance, Dewenter and Haucap (2005) applied pooled estimation to test the effects of the MTR regulation and the operators' market size on MTRs. The next one was from Littlechild (2006). The author applied simple linear regressions and found that the receiving party pays (RPP) regime significantly decreased the price but increased the usage by mobile subscribers. However, the first to find the impacts, empirically, of MTRs on prices were Genekos and Valletti (2011), first brought to the public in 2007. They used the fixed-effect (FE) technique, combined it with the instrumental variable (IV) regression model and found that lowering MTRs would lead to an increase in retail prices. Following the paper by Genekos and Valletti (2011), the empirical evidence on the impacts of MTRs has been produced accordingly by Hansen and Andersson (2009), Veronese and Pesendorfer (2009), Cunningham, Alexander and Candeub (2010), Growitsch, Marcus and Wernick (2010), and Dewenter and Kruse (2011). The methodologies are similar in concept but different in detail, while, interestingly, some of the results of these studies are contradictory. A summary of the previous empirical studies on the impacts of MTRs is presented in Table 1.

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<sup>2</sup> The waterbed effect concept is explained in detail in Section 4.

Table 1: Summary of the empirical literature review on the impacts of MTRs

Author(s)	Dependent Variable(s)	Independent Variable(s)	Data/time	Source	Methodology	Main conclusion and recommendation
Genekos and Valletti (2011), first presented to the public in 2007	prices, firm profits	MTRs (instrumented by regulation), prepaid best deal dummy	matching difference sources from 1999 to 2006 (collected quarterly) from mobile operators in 24 countries	Cullen International/ Teligen/ Merrill Lynch	IV approach with fixed-effect specification	The authors estimated the impacts of MTRs on retail prices and the operators' profits. Their results showed that MTRs have significantly negative impacts on retail prices.
Hansen and Andersson (2009)	function of firm profits, market share and no. of customers	functions of MTRs, average minutes and no. of mobile operators	26 mobile operators from 9 countries in north-western Europe from the 1 <sup>st</sup> quarter of 2003 to the 3 <sup>rd</sup> quarter of 2006	Ovum/ Wireless Intelligence	GMM <sup>3</sup> cluster-fixed effect	The authors used the multi-firm competition model and applied it to the econometric regression to estimate the impacts of MTRs on the operators' profits. Their results showed that the hypothesis of profits not being affected by cutting MTRs cannot be rejected. They therefore suggested that lower MTRs in a mature market would not necessarily benefit consumers.
Veronese and Pesendorfer (2009)	penetration rates, minutes of use, prices	retail regime, MTRs, GDP per capita, population density, fixed penetration, region dummy	39 OECD countries from 2002 to 2007	Merrill Lynch/ Teligen/ ITU/ World Bank	country random effect specification with the fixed components estimated by GLS <sup>4</sup>	The authors estimated the impacts of MTRs on social welfare proxies consisting of mobile penetration, minutes of use and retail prices (proxy by average revenue per minute). Their results showed that MTRs have significantly positive effects on mobile penetration and retail prices, but the results were not robust in the minute of use variable.

<sup>3</sup> Generalised method of moments

<sup>4</sup> Generalised least squares

Author(s)	Dependent Variable(s)	Independent Variable(s)	Data/time	Source	Methodology	Main conclusion and recommendation
Cunningham, Alexander, and Candeub (2010)	mobile subscription	retail regime, MTRs, no. of mobile operators, government ownership, Internet subscription, fixed termination rates, pop. density, GDP, average age of population, interaction between no. of mobile operators and MTRs, etc.	85 countries in 2003 (apply 2004 data for dependent variable)	ITU/ Global Comms Database/Merrill Lynch	OLS <sup>5</sup> and measuring the explanatory variable with time lag whenever possible	The authors estimated the impacts of MTRs on mobile subscriptions per person. They found that MTRs had a significantly positive effect on mobile subscriptions, however, the results of the coefficients on the interaction between MTRs and the number of operators are significantly negative. These results suggested that MTRs can be considered as a weaker variable if the market is competitive.
Growitsch, Marcus and Wernick (2010)	minutes of use, prices (proxy by voice revenue per minute)	lagged minutes of use, prices, MTRs, subscriber (in the price model, the authors use only MTRs)	61 mobile operators from 16 European countries from 2003 to 2008	BEREC(REG)/ Merrill Lynch	System-GMM approach to Houthakker-Taylor model	The authors estimated the impacts of MTRs on retail prices using MTR lagged values as an instrument. Their results showed that lower MTRs also tend to reduce the mobile retail prices.
Dewenter and Kruse (2011)	Dependent: diffusion rates	retail regime, competition, prepaid card, fixed telephone lines per capita, population, population density, GDP per capita (retail regime and competition also instrumented with several regulation variables)	84 countries from 1980 to 2003	ITU/ World Bank published data from several regulators	IV approach with fixed effect specification	The authors compared CPP and RPP regimes, similar to Littlechild (2006), but focused on the penetration rate. They found that there is no significantly different impact between CPP and RPP and concluded that the RPP regime is preferred as it can avoid the regulatory cost.

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<sup>5</sup> Ordinary least squares

Not all researchers agree with the econometric approach to finding the impacts of MTRs. For example, Stork (2011) criticised the fact that considering a specific country in detail could provide a better analysis than a cross-country econometric approach. The author claimed that the econometric studies could not explain the pricing behaviour of operators after interventions from regulators. Nevertheless, this paper continues to follow the previous cross-country econometric studies to support more empirical evidence as this will be fruitful for future research. From the econometric analysis, this paper also provides the graphical and statistical analysis of secondary data.

## **4. Theory Discussion**

### **4.1 The two-sided market**

The two-sided market, also called two-sided networks or a two-sided platforms, can be described briefly as a market in which one or more platforms can create an interaction between two agents. When the variable(s) in each platform change(s), this affects the agents' surplus or deficit. According to Rochet and Tirole (2004), the theories behind the concept of the two-sided market are network externalities and price discrimination between the two sides. Obvious examples of the two-sided market are credit card platforms, video game consoles, communication networks, matching agents, etc. According to Evans (2003), the two-sided market can be divided into following four categories.

- Exchanges category: the exchanges provide a platform to support the customers from both sides by increasing (positive) network externalities. The more customers (members), the more benefits both sides get. Examples of this group are brokers, eBay, house rental agency, dating agency, and employment agency.
- Advertising-supported media category: the media supports the platform for both advertiser and viewer sides. The more viewers, the more positive externalities advertisers get. On the other hand, the viewers can have different attitude towards advertisement, negative, indifferent or positive; however, the viewers generally feel that advertisement is negative externalities for them. Examples of this platform are magazine, newspaper, free television, and web portal.
- Transaction systems category: the obvious example of this category is credit card system. The credit card system provides buyers (card holders) and sellers to have transactions on its platform. The externalities are more complicated in this category depending on the annual fee, the charge fee, the discount, etc.
- Software platforms category: Software platform supports the application market as a platform for application users and software developers. The software platform reduces the cost for both users and developers, and implicitly encourages more supply in the application market. Examples of this group are personal computers (PCs), video games, and music players.

A number of researchers, for example, Valletti (2006), claimed that the mobile market can be explained as a two-sided market in exchange category where subscribers (callers and receivers) benefit from communication, and MTRs can be considered one side of the two-sided market. To determine that the mobile market is the platform of the two-sided market, the special characteristics of the mobile market need to be considered. First, like a matching agent platform (for example, a dating agency or house rental agency) in which more members provide greater probabilities of the agents matching the members, network externalities can be seen in the mobile market where mobile operators act as a platform because the sender and the receivers will have more utilities when using the phone if they have more communications. Second, the price discrimination in the mobile market can be seen as the on-net call and off-net call<sup>6</sup>, when mobile operators often set the off-net price higher than the on-net price. Mobile operators also normally apply price discrimination to use at different times, for example, calling at peak time is commonly more expensive than at off-peak time. According to the two reasons above, it can be implied that mobile termination is one side of a two-sided market.

The mobile market is currently in a competitive environment, however, in which mobile penetration in several countries in the EU is very high, in some countries even above 100%. Rochet and Tirole (2004) mentioned that the markets can be considered as de facto one-sided markets if they are highly competitive. Nevertheless, despite this dramatically growing competition, the price structure in the mobile market is still crucial and this paper cannot rule out the two-sided market assumption despite the competitiveness of the market.

With the complexity of MTRs in the two-sided market, theory alone cannot fully describe this complicated relationship between MTRs and the other side of the market. Empirical evidence is therefore needed to suggest appropriate MTR regulation to the regulators.

#### **4.2 The waterbed effect**

The waterbed effect theory is normally described as a result produced by the two-sided market. Generally, the waterbed effect, which comes from the waterbed theory, is used to explain the situation when one spot of a complex system is pushed down and the other spot rises up to compensate. In terms of MTRs, the waterbed effect applies when the reduced MTRs affect the other services, such as retail prices, mobile usage and mobile penetration, etc. In fact, the waterbed effect not only affects the change in the price but also the change in the quality, quantity and variety of the services (Schiff 2008). Nevertheless, the waterbed effect from MTRs is usually seen as the effect on the retail price or mobile penetration.

There have been disagreements on the waterbed issue. The mobile operators usually claim that the effect is significant and that lower MTRs can be seen as a drawback, while the regulator side often finds that the effect is small and does not have any impact on social

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<sup>6</sup> An on-net call is a call made by a caller and receiver with the same mobile operator while an off-net call is a call made by a caller and receiver from different mobile operators.

welfare with respect to decreasing MTRs (Littlechild 2006). The waterbed effect was sometimes, interestingly, interpreted differently in previous empirical studies. For example, Genekos and Valletti (2011) explained their evidence of the waterbed effect with MTRs having a negative effect on prices. Growitsch, Marcus and Wernick (2010), however, mentioned the existence of the waterbed effect with MTRs having a positive effect but a coefficient of less than 1 for prices.

According to the complexities of the waterbed effect, whether or not it exists, regulators should be very careful before intervening at the MTRs price level. The empirical evidence can therefore support the regulators' decision, along with the concept from theories and mathematic modelling.

## 5. Methodology, Model Specification and Data Description

### 5.1 Methodology and Model specification

Firstly, MTRs can be considered both a cost and revenue for mobile operators. MTRs can also be used for price discrimination between on-net and off-net prices. The MTR variable is therefore selected as the main explanatory variable. In dynamic panel data, the lagged value of price (price in the past) is chosen as an explanatory variable as it can determine the current price. For other variables, population density and gross domestic product (GDP) per capita are also selected. The population density and GDP per capita variables were also chosen by Veronese and Pesendorfer (2009), Cunningham, Alexander and Candeub (2010), and Dewenter and Kruse (2011). Veronese and Pesendorfer (2009) explained that GDP per capita can reflect the consumers' average incomes and even relate to labour cost, which is important to determining the price. Population density is considered a demo-geographic variable that can affect the cost relating to infrastructure investment. Nevertheless, other time-constant variables, such as spectrum frequencies, number of operators and regulation in each country, which are mostly constant over time in this dataset, are omitted because the applied econometric model in this paper can control this type of explanatory variables. The penetration rate in each country is also omitted because the mobile penetration rates in most European countries have now already been close to or more than 100% and can be assumed irrelevant in the models. For the purpose of this paper, which focuses on the MTR variable, the other variables are captured by the error terms in the models.

The methodologies applied in this paper follow the previous literature with the concept of combining the instrumental approach to panel data; however, the details are different. This paper applied the one-step difference generalised method of moments (GMM) approach suggested by Arellano and Bond (1991) on dynamic panel data and adapted from Dewenter and Haucap (2007). The purpose of this approach is to solve the econometric problems that can occur with the dynamic panel model. The dynamic panel model in this paper is shown in equation (1):

$$\ln price_{it} = \alpha_i + \beta_i \ln price_{i,t-1} + \gamma_i \ln mtr_{it} + \delta_{ik} X_{itk} + u_{it} \quad (1)$$

From model (1),  $\ln price_{it}$  is the logarithm function of the retail price while  $\ln price_{i,t-1}$  is the lagged value of  $\ln price_{it}$ .  $\ln mtr_{it}$  is the logarithm function of MTRs.  $X$  presents the other explanatory variables, which are population density and GDP per capita, and finally  $u_{it}$  is the error component consisting of the time-invariant ( $v_i$ ) and time-variant ( $e_{it}$ ) characteristics ( $u_{it} = v_i + e_{it}$ ). According to equation (1), there are three main econometric problems to be concerned with, which if only applied to OLS would provide the biased estimators. First, the time-invariant country characteristics, such as geography, are likely to be correlated with other independent variables. Second, the endogeneity problem of MTRs may be correlated with the error terms. Third, using the lagged value of price as a regressor in the dynamic model leads to the autocorrelation problem. The first and second problems can be solved using IV along with the fixed effect regression on the panel data. However, it is difficult to provide an appropriate instrument for MTRs. To avoid the weak instrumental problem that makes the FE-IV estimation bias as similar to OLS estimation, the lagged value of MTRs is used as an instrumental variable instead. With the use of the lagged value of MTRs and the lagged value of price as a regressor, a suitable approach to estimate the model, which can produce the autocorrelation problem, is the GMM estimation. In this paper, the one-step difference GMM estimation is chosen. The one-step difference GMM can transform the model (1) into model (2):

$$\Delta \ln price_{it} = \beta_i \Delta \ln price_{i,t-1} + \gamma_i \Delta \ln mtr_{it} + \delta_{ik} \Delta X_{itk} + \Delta e_{it} \quad (2)$$

By applying the first difference in equation (1), it can be seen that the constant term and the time-invariant characteristics are taken off in equation (2). The first econometric problem is therefore solved. The second problem is solved using the lagged value of MTRs as an instrument and, lastly, the third problem is solved when applying GMM, since the GMM approach is more efficient than the FE-IV method when dealing with the serial correlation problem. The Arellano-Bond one-step GMM approach is therefore suitable for data with a short period of time (small  $t$ ) compared with  $i$  countries, which is the characteristic of the data used in this paper. The variable explanations are shown in Table 2.

Table 2: Description of variables

Variables	Descriptions
<b>Dependent Variable:</b>	
$\ln price_{it}$	the natural logarithm function of retail prices for country $i$ at time $t$
<b>Independent Variables:</b>	
$\ln price_{i,t-1}$	the first lagged value of the natural logarithm function of retail prices for country $i$ at time $t$
$\ln mtr_{it}$	the natural logarithm function of MTRs for country $i$ at time $t$
$\ln gdp_{it}$	the natural logarithm function of GDP per capita for country $i$ at time $t$
$density_{it}$	population density (person/km <sup>2</sup> ) for country $i$ at time $t$

Despite the benefit of using the GMM approach, some econometricians suggest the caveat of applying the use of an instrument in panel data. For example, Brüderl (2005) criticised

that dynamic panel data and the use of the GMM estimator (or other IV) depended on the untestable assumption that the instrument variables are not correlated with the error terms, which could lead to incongruity results and take away the benefit of the panel data model. This paper therefore also provides the results from the classical FE model to present the consistency of the impacts of MTRs on retail prices. For a classical FE model, equation (3) follows the earlier study by Veronese and Pesendorfer (2009)'s initial model ( $y_{it} = \beta X_{it} + u_{it}$ ).

$$\ln price_{it} = \alpha_i + \beta_i \ln mtr_{it} + \gamma_{ik} X_{itk} + u_{it} \quad (3)$$

In model (3), it is approached by traditional FE regression in which there is no instrument for MTRs to solve the unobserved heterogeneity. The FE model can take off the time-invariant components; however, there is a strong assumption that the explanatory variables are not correlated with time-variant error terms:  $Cov(x_{it}, e_{is}) = 0$ . If this assumption is true, the classical FE model will be more appropriate than the GMM or FE-IV approach. If not, the classical FE estimator will be biased.

## 5.2 Data description

The panel dataset in this paper includes information from 33 countries<sup>7</sup> in Europe from 2006 to 2011. However, some of the variables in 2006 and 2011 are missing, which has resulted in the empirical analysis in this paper covering 2007 to 2010 instead. The MTR dataset was collected from BEREC (formerly ERG), which provides a country average of MTRs every six months. Next, the retail price dataset was obtained from the ITU database. The annual country average of prepaid off-peak, off-net prices was selected to represent the retail prices. According to the EC 15<sup>th</sup> Report (2010), even the proportion is declining: in October 2009, the majority of mobile subscribers was still prepaid customers, at 55.3%. Many previous studies also implied that the low to medium usage consumers who were prepaid subscribers would be worse off than the postpaid users. For example, Frontier (2008) pointed out that prepaid plans in countries with low MTRs, such as the USA, were not as attractive as the ones in Europe. The prepaid price is therefore very sensitive to decreasing MTRs. Lastly and importantly, the annual country average prepaid off-peak, off-net prices are also the most consistent and are available from the ITU price category dataset. Nevertheless, the annual country average prepaid off-peak, off-net prices are recorded consistently from 2008 onwards while only a few countries recorded them in 2007 and none in 2006. Other explanatory variables are the GDP per capita, which is obtained from the World Bank's online database, and the population density, which is also collected from the ITU and the World Bank database. Lastly, the price data from the ITU were recorded in US

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<sup>7</sup> The thirty-three countries are Austria, Belgium, Denmark, Germany, Finland, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Sweden, Switzerland, Spain, the UK, Iceland, Hungary, Romania, Bulgaria, the Slovak Rep., Estonia, Lithuania, Malta, Macedonia, Slovenia, the Czech Rep., Cyprus, Latvia, Poland, Turkey and Croatia.

dollar units while the MTR dataset is in euro cent units. The annual exchange rate from [www.oanda.com](http://www.oanda.com) is therefore applied. The statistic summary of variables is shown in Table 3.

Table 3: Statistic summary of variables

Average for all years

Variable	Observation	Mean	Std. Dev.	Min	Max
Price (euro)	206	0.2522	0.1516	0.0657	0.6841
MTRs (euro)	383	0.0807	0.0339	0.0145	0.1910
GDP per capita (euro)	330	24031	16773	2559	80792
Pop. density (person/km <sup>2</sup> )	394	154.10	223.55	2.92	1321.6

2006

Variable	Observation	Mean	Std. Dev.	Min	Max
Price (euro)	NA	NA	NA	NA	NA
MTRs (euro)	62	0.1124	0.0322	0.0224	0.1910
GDP per capita (euro)	66	23074	16546	2559	71758
Pop. density (person/km <sup>2</sup> )	66	152.08	222.44	2.92	1300.9

2007

Variable	Observation	Mean	Std. Dev.	Min	Max
Price (euro)	8	0.3968	0.1938	0.2124	0.6841
MTRs (euro)	64	0.1021	0.0294	0.0205	0.1844
GDP per capita (euro)	66	24649	17347	2912	78126
Pop. density (person/km <sup>2</sup> )	66	152.81	223.31	2.97	1305.7

2008

Variable	Observation	Mean	Std. Dev.	Min	Max
Price (euro)	66	0.2653	0.1495	0.0657	0.6834
MTRs (euro)	61	0.0886	0.0263	0.0201	0.1826
GDP per capita (euro)	66	24989	17211	3274	80792
Pop. density (person/km <sup>2</sup> )	66	153.52	224.09	3.02	1310.0

2009

Variable	Observation	Mean	Std. Dev.	Min	Max
Price (euro)	66	0.2485	0.1438	0.0657	0.6832
MTRs (euro)	64	0.0745	0.0245	0.0195	0.1353
GDP per capita (euro)	66	23047	15872	3257	75047
Pop. density (person/km <sup>2</sup> )	66	154.19	224.83	3.06	1314.0

2010

Variable	Observation	Mean	Std. Dev.	Min	Max
Price (euro)	66	0.2254	0.1481	0.0658	0.6839
MTRs (euro)	66	0.0628	0.0217	0.0167	0.1075
GDP per capita (euro)	66	24394	17260	3367	79593
Pop. density (person/km <sup>2</sup> )	66	154.82	225.57	3.11	1318.1

Variable	Observation	Mean	Std. Dev.	Min	Max
Price (euro)	NA	NA	NA	NA	NA
MTRs (euro)	66	0.0468	0.0160	0.0145	0.0853
GDP per capita (euro)	NA	NA	NA	NA	NA
Pop. density (person/km <sup>2</sup> )	64	157.30	229.71	3.09	1321.6

### 5.3 Limitation

First, the methodology has a few limitations. Theoretically, the system GMM, as applied in Growitsch, Marcus and Wernick (2010), is more efficient than the difference GMM in this paper. However, the system GMM requires a large number of datasets to create more instruments. The difference GMM is therefore more appropriate to this paper with a smaller dataset. Only the second lagged value of MTRs, applied as an instrument, is used in this paper as the first lagged value cannot be used due to its correlation with the error terms, and the large number of instruments (other lagged values that are deeper than the second lag) will cause the over-identification tests<sup>8</sup> to be weak. Second, some may argue that the annual average prepaid price cannot on its own completely represent the retail price; however, as explained earlier, the prepaid price is the best available in this dataset that can reflect the retail price. Third, with limited data, all the variables besides MTRs are collected annually; therefore, they are recorded at the same value in each half of the same year. Lastly, MTRs can affect not only prices but also other factors, such as handset subsidy and mobile usage. The retail prices cannot reflect all social welfare. This limitation therefore leaves room for future research to explain the impacts on other factors.

### 6. MTRs and Regulation

Since 2001 when the EC set up the framework to regulate MTRs for member countries, many regulators in the member countries have tried continuously to reduce MTRs. Nevertheless, the efficiency of each country differs. According to the data from the European Regulators Group (ERG) in 2006, the gap in the MTR range in the EU is still high with the lowest MTR in 2006 being 2.24 euro cents in Cyprus and the highest in 2006 being 19.1 euro cents in Bulgaria. Therefore, in 2009, the EC clearly told its members to apply the LRIC principle to regulate MTRs in each country before the end of 2012 in the hope that the MTRs and the gap between member countries would reduce to approximately 1.5-3 euro cents. Many regulators in the EU tried to follow the EC with a cost-based regulation framework; however, the details are slightly different. Examples of regulation in selected countries are presented in Table 4.

<sup>8</sup> The over-identification test has the null hypothesis that the instruments as a group are exogenous and valid. Therefore, the higher the p-value, the better that the null hypothesis cannot be rejected. The over-identification test is known as the Sargan test if the error terms are homoscedastic or the Hansen test if the error terms are not homoscedastic.

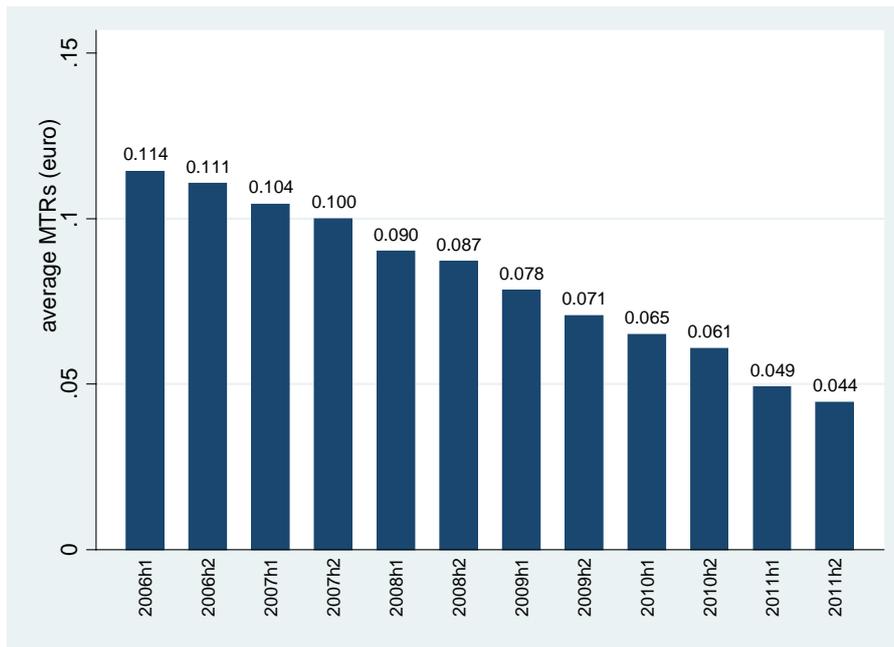
**Table 4: MTRs regulation in selected European countries**

Country	MTRs Regulation
Austria	MTRs must be cost-oriented (Long Run Average Incremental Cost; LRAIC) and all mobile operators must have similar MTRs.
Belgium	MTRs are based on cost orientation and gradually towards pure LRIC and symmetry between three mobile operators in 2013.
The Czech Republic	MTRs are set by mobile operators but cannot exceed the price cap calculated by the operator with the lowest costs of termination.
Estonia	MTRs are regulated by the price cap, which is a benchmark of the EU average.
France	MTRs are regulated using pure LRIC as a price cap, which mobile operators use as actual prices.
Ireland	Using a glide path to gradually reduce MTRs to an average rate of 5 euro cents per minute before the end of 2012.
Portugal	MTRs are regulated by a price cap that is a benchmark from six countries: Austria, Finland, France, Italy, Romania and Sweden.
Slovenia	Using a glide path from LRIC plus and asymmetry for new entrants in 2009 to pure LRIC and symmetry in 2013.
Sweden	MTRs must be cost oriented if mobile operators have significant market power (SMP).
Switzerland	MTRs are set by operator negotiation while the regulator only makes the decision in a dispute case.

Source: OECD 2011

At the end of 2011, the lowest MTRs were in Turkey, averaging 1.45 euro cents, and the highest average was in Luxembourg, at 8.53 euro cents. It can be seen that the EC framework was effective from 2006 to 2011 for MTRs and the gap has continued to decrease as planned. Figure 2 shows the decrease in average MTRs in Europe from 2006 to 2011.

Figure 2: Average MTRs in the EU area from 2006 to 2011



Source: BEREC/ERG

From Figure 2, the average MTR at the start of 2006 is approximately 11.4 euro cents while at the end of 2011, the average MTR has decreased to 4.4 euro cents.

As discussed earlier, however: is the regulation to reduce MTRs going in the right direction? Several mobile operators, especially those with a high market share, did not agree that it is the right direction. Many studies from the operators' side, such as Fors and Steen (2008), Frontier Economics (2008) and Telecom Italia (2008), argued that cutting MTRs does not necessarily lower the price and there is no evidence that below-cost MTRs are efficient. They also pointed out that reducing MTRs could affect the loss to prepaid users. In contrast, the EC believed that lower MTRs would encourage competitiveness in the market as it would support fixed operators as well as small mobile operators. Moreover, despite the competitiveness of the retail market, the unique characteristics of mobile termination in the CPNP regime, network externalities and tariff-mediated network externalities, along with customer ignorance of MTRs, would lead to a termination monopoly problem. MTR regulation is therefore needed. The next section presents results as further evidence on whether lower MTRs is an appropriate strategy.

## 7. Empirical Results and Discussion

The econometric results from traditional FE, including the Random Effect (RE) model and one-step difference GMM estimations as discussed in Section 4, are shown in Table 5.

Table 5: Regression results

<b>Dependent variable: <math>\ln price_{it} / \Delta \ln price_{it}</math></b>				
<b>Variables</b>	<b>FE</b>	<b>RE</b>	<b>GMM1</b>	<b>GMM2</b>
$\Delta \ln price_{i,t-1}$	-	-	0.0998	0.5371***
	-	-	(0.1797)	(0.1800)
$\ln mtrs_{it} / \Delta \ln mtr_{it}$	0.3717*	0.4089***	0.5200**	0.5286*
	(0.1944)	(0.1436)	(0.2526)	(0.3086)
$density_{it} / \Delta density_{it}$	0.0212	0.0004*	0.0011	0.0229
	(0.0292)	(0.0002)	(0.0140)	(0.0217)
$\ln gdp_{it} / \Delta \ln gdp_{it}$	-0.2748	-0.0622	-0.2746	-0.1803
	(0.6991)	(0.1055)	(0.4413)	(0.6590)
constant	-1.1002	0.1100	-	-
	(5.7764)	(1.2082)	-	-
time dummies	yes	yes	no	yes <sup>9</sup>
observation	199	199	135	135
no. of groups	33	33	33	33
R-square	0.2072	0.2015	-	-
F-test/Wald chi2	2.11*	33.74***	3.67**	6.26***
Hausman test	Prob > chi-square = 0.9988		-	-
Hansen test	-	-	Prob > chi2 = 0.235	Prob > chi2 = 0.510

The standard errors (clustered/robust) are presented in parenthesis under the coefficients. The significant levels are reported in \*, \*\*, \*\*\* symbols: \*significant at 10% \*\*significant at 5% \*\*\*significant at 1% of the critical values.

The first model is the FE model with clustered errors by countries. The Hausman test statistic indicates that the estimators from the RE model are as consistent as the ones from the FE model. The RE model with clustered errors by countries is therefore also added and presented in the second model. However, despite the fact that we cannot reject the null hypothesis from the Hausman test, which means that the RE model can provide more efficient estimators, it is important to bear in mind that the RE model requires a very demanding assumption of no correlation of explanatory variables and error terms, and the Hausman test does not usually work very well in a small dataset, which is a limitation of this paper. Nevertheless, the FE and RE models both provide results in the same direction, especially considering the MTRs aspect. The third and fourth models use the Arellano-Bond one-step difference GMM approach (robust standard errors) without and with time dummies respectively.

According to the results in Table 4, all models provide significant coefficients for MTRs of at least a 10% critical value significance level. The F-test and the Wald chi-square test show that the models are valid and significant at, at least 10% critical value in the FE model and at, at least 5% critical value in the other models. The Hansen test also proves that the group of instruments in both GMM models are exogenous. All the models also indicate that the results, with respect to the effects of MTRs on the retail price, are robust. While the coefficients of population density and GDP per capita are insignificant, the coefficients of

<sup>9</sup> Only the second halves of the year are used as time dummies in the GMM model to limit the number of instruments that can weaken the over-identification test.

MTRs in all models vary from approximately 0.37 to 0.53 and have a positive sign. These results can support the hypothesis that lower MTRs will also decrease the consumer retail prices. For interpretation, given that the fourth model is the preferred one and that the others are references, the coefficient parameter of  $\Delta \ln mtr_{it}$  compared with the  $\Delta \ln price_{it}$  can be seen as a measure of the elasticity of the retail prices (Growitsch, Marcus and Wernick 2010). The 0.5286 coefficient of  $\Delta \ln mtr_{it}$  therefore implies that 10% lower MTRs will lead to a decrease in the retail prices of 5.29%.<sup>10</sup> Compared with previous studies, this result is also consistent with the studies from Veronese and Pesendorfer (2009), and Growitsch, Marcus and Wernick (2010).

With these statistically significant and robust results, along with the consistency with previous studies, it can generally be concluded that MTRs have significant positive impacts on the retail prices. These impacts mean that decreasing MTRs will lead to lower retail prices while increasing MTRs will encourage higher prices. The approach by the EC since 2008 to reduce MTRs efficiently therefore leads to a decrease in retail prices. To be precise, retail prices are considered an important factor in representing consumer welfare. It can therefore be said that lower MTRs can implicitly increase consumer welfare as well as overall social welfare.

## **8. The Implication for Regulators and Future Research**

With the results from the previous section, this empirical evidence supports the idea that it is appropriate for the EC to lower and regulate MTRs before the end of 2012, and other regulators with a CPNP regime from other regions should follow this framework. Even though MTRs do not directly affect customer welfare, MTRs are important determinants for setting retail prices that easily relate to consumer welfare for the following reasons:

1. Lowering the prices can lead to higher consumer consumption, which can ultimately imply higher consumer welfare.
2. Lowering MTRs can indirectly reduce the gap between on-net and off-net call prices, which can be seen as a strategy by large operators to create a barrier to small operators competing or entering the market. With the smaller gap, the market will finally be more competitive.
3. Gradually Lowering MTRs can be considered a suitable glide path for the BAK regime, if necessary, without dramatic impacts on mobile operators.

According to the supporting reasons above, it is recommended that regulators in the CPNP regime reduce MTRs to at least the same level as the operators' cost to raise overall social welfare, especially consumer welfare (this can leave room for discussion on which operator

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<sup>10</sup> According to model specification in model 4, the coefficient of  $\Delta \ln mtr_{it}$  can capture only short run effect. To calculate the long run coefficient, the short run coefficient is divided by  $(1 - \text{coefficient of } \Delta \ln price_{i,t-1})$ . Therefore, the long run coefficient is equal to 1.1419

cost should be applied). However, the speed of reducing MTRs can also differ between countries depending on their individual situations.

For future research, this paper only presents the effects of MTRs on retail prices. As mentioned earlier in the limitation, practically, MTRs may affect mobile subscription, mobile usage, etc. The retail price is not the only factor of consumer welfare however, and several factors should be considered as consumer welfare. It would therefore be very interesting to analyse these other factors in future research. Moreover, this paper only analyses the voice call aspect; hence, with the convergence of technology, it would be more fruitful to consider other types of interconnection in the ICT sector in the future when the data become available, for example, the impacts of wholesale international roaming agreements, Inter Operator Tariffs (IOTs), on international roaming prices, the appropriate approach to regulate IP-based interconnection, etc.

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