# HOW SHOULD REGULATORS APPROACH TO THE RELATIONSHIP BETWEEN "MOBILE NETWORK OPERATORS" AND "MOBILE VIRTUAL NETWORK OPERATORS"? AN ASSESSMENT FOR THE CASE OF TURKISH MOBILE MARKET

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**September 2009**

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| | |
|---|---|
| 3G | Third Generation Mobile Networks |
| AUC | Authorisation Centre |
| BTS | Base Transceiver Station |
| ComReg | Communications Regulator (Ireland) |
| ECAP | Electronic Communications Appeals Panel (Ireland) |
| ECPR | Efficient Component Pricing Rule |
| EIR | Equipment Identity Register |
| FCC | Federal Communications Commission |
| G(MSC) | Gateway MSC |
| GSM | Global System for Mobile Communications |
| HHI | Herfindahl-Hirschman Index |
| HLR | Home Location Register |
| ICTA | Information and Communication Technologies Authority |
| IN | Intelligent Network |
| ITU | International Telecommunications Union |
| MIC | Ministry of Internal Affairs and Communications (Japan) |
| MMS | Mobile Multimedia Services |
| MNO | Mobile Network Operator |
| MSC | Mobile Switching Center |
| MVNO | Mobile Virtual Network Operator |
| NMT | Nordic Mobile Telecommunications |
| NPT | Normative Analysis as a Positive Theory |
| OFCOM | Office of Communications (The UK) |
| OFT | Office of Fair Trading (The UK) |
| RAC | Radio Access Controller |
| SCT | Special Communications Tax |
| SIM | Subscriber Identity Module |
| SMS | Short Messaging Services |
| TA | Telecommunications Authority (Turkey) |
| TMC | Telecommunications Market Commission (Spain) |
| UMTS | Universal Mobile Telecommunications System |
| VAT | Value Added Tax |

**ACKNOWLEDGEMENTS**

I would like to express my gratitude to my advisor, Dr. Xeni Dassiou, for her supervision and invaluable suggestions throughout this dissertation work.

Besides my advisor, I am grateful to the staff on the Department of Economics of the City University London who taught me during my MSc program.

And my sincere thanks go to my parents, my wife and two kids for their love, support and understanding during my study.

## DECLARATION

"I grant powers of discretion to the Department of Economics to allow this dissertation to be copied in whole or in part without any further reference to me."

**ABSTRACT**

Almost everyone agree that the natural monopolies in fixed telecommunication markets should be regulated to open their bottleneck facilities to the newcomers to facilitate entry after the liberalization. Because the owners of these bottleneck facilities both supply the input to the entrants and provide services to end users, and thus may have an incentive to refuse the access of the new entrants to their bottleneck facilities. But the situation is somewhat different in mobile sector because of its oligopolistic and competitive market structure from the start of providing mobile services.

Although allowing MVNOs to operate is seen as one of the tools to increase competition in the mobile telecommunications sector, it is not clear in advance whether MNO-MVNO relationship should be regulated or not. Relying on both theoretical and empirical research this paper seeks an answer from economics point of view for the question whether MNO-MVNO relationship in Turkey where MVNOs have been allowed to enter the market recently should be regulated or not. In the light of the economic analyses and taking into account the current situation in the Turkish mobile market, the paper argues that the Turkish regulator shouldn't intervene in the MNO-MVNO relationship for now and continue to monitor the market forces at least until one of the parties apply to the regulator for a dispute resolution. But, even if one of the parties comes with such an argument, before imposing an obligation on MNOs, the regulator should assess whether the market is sufficiently competitive. Should it find that the market forces are working properly, there is no reason for regulatory intervention even if there are no contractual relationships between MNOs and MVNOs.

## 1. Introduction

Mobile telecommunications markets can be characterised as oligopolistic markets because of the limited number of operators that can be authorized to provide mobile services due to the technical constraints stemming from scarcity of frequencies. This technical constraint or scarcity of the frequencies allows about 5-6 firms[1] to be allocated spectrum in each country and makes it impossible to allocate new frequency blocks to the new firms. This limitation constitutes a technical barrier for the candidate operators to provide mobile telecommunication services in the future. Moreover, the huge amount of investment required to develop and run the network and to cover the most of the population constitutes other important barriers to entry for new operators.

Fortunately, the development of technologies brought about many innovations in mobile markets, and with the aid of some developments the spectrum of mobile network operators could have also been used by other operators by sharing for about 10 years. In this study the facility-based operators which have the licences or the right to use frequencies and own spectrum are referred to as Mobile Network Operators (the MNOs) or host operators, and the service-based operators which provide mobile telecommunications services using the frequencies and certain network elements of the MNOs are referred to as Mobile Virtual Network Operators (the MVNOs). MVNOs do not hold spectrum licences from governments but rely on the MNOs` frequencies if both of the parties could manage to come to an agreement either voluntarily or mandatorily to use the frequencies and some network elements by sharing.

Introducing MVNOs to mobile markets may have some pros and cons for the sector. MVNOs may stimulate competition and innovation if they could enter the market. They can help MNOs by reaching some niche markets that MNOs have not reached, and MNOs can also benefit from MVNOs by getting wholesale rents. Although it is difficult to anticipate in advance the impact of MVNOs on the investment incentives of MNOs as MNOs have a potential to benefit from customer base of MVNOs and wholesale rents from them; obliging MNOs to share their networks with MVNOs may reduce the MNOs` incentives to invest in their networks because of the dissatisfaction of not appropriating the full benefits from their investment. Moreover, MVNOs could steal customers from MNOs and, from an MNO point of

[1] The frequency block reserved by the International Telecommunications Union (ITU) for the provision of the 3G (UMTS) technologies for all countries is 2x60 MHz paired and 35MHz unpaired spectrum. UMTS Forum, one of the standard development organizations which developed the UMTS technology, recommends that each operator in each country should be allocated 2x15 MHz paired and 5 MHz unpaired spectrum in the initial phase because of the technical reasons and efficient provision of services (http://www.umts-forum.org/content/view/1477/7/). As of July 2008 (EC, 2009), the average number of mobile operators in EU was 3.6 with 5 operators in 4 countries and 2 operators in 2 countries.

view MVNOs mean sharing the market with them. Another concern for the MNOs is the greater customer churns, because an MVNO is an alternative for customers and introducing MVNOs increases the likelihood of churn rates.

Although it can be foreseeable that MVNOs stimulate competition which results in lower prices and higher consumer welfare; some countries prefer mandating MNOs for MVNO access[2], and others leave it to the commercial agreements between the parties. For example, Spain and Hong Kong have specific regulatory provisions for MVNOs (i.e. some operators are obliged to reserve certain amount of capacity for MVNOs); but some other countries such as the USA and the UK have no access obligations. The fact that the MNOs are obliged to provide access to MVNOs in some jurisdictions but not in others brings about the issue whether MNO-MVNO relationship should be regulated or not for more effective competition.

In almost all countries where there has been only one fixed national network before the liberalization, it is accepted that these natural monopolies should be regulated to open their bottleneck facilities to the newcomers. Because the owners of these bottleneck facilities provide services to end users and thus may have an incentive to refuse the access of the entrants to their bottleneck facilities. But the situation is somewhat different in mobile sector because of its oligopolistic and competitive market structure from the start of providing mobile services. As discussed in chapter 3, there are different economic approaches on whether the access providers should be regulated or not if the bottleneck facility providers are competitors in the upstream and downstream markets rather than monopolies.

To examine the relationship between MNOs and MVNOs we can rely on the relevant economic theories focusing on the provision of an essential input, used to produce an output, to the newcomers or foreclosing them. If regulators find that the MVNOs` entry is prevented because of market failure, then regulatory obligation for MNOs might be justified. But, if it is established that the access providers are most likely to supply the access seekers voluntarily because of bilateral contributions to the parties, then there is no rationale to intervene in the market forces.

In Turkey, MVNOs have been allowed to enter the market recently and 5 MVNOs notified the Turkish regulator and the regulator endorsed their notifications in June and July 2009. But they have not yet been operational and they are in the phase of finding a partner for now. This market condition suggests that the Turkish regulator will face with a problem if an MNO-

[2] The term "access" is used to define the case that MVNOs use the MNOs` facilities to provide mobile services, but MNOs do not need to use the MVNOs` facilities. This kind of access corresponds to the "one-way access" in economics literature as discussed in section 3.3.

MVNO relationship can not be established between the parties. So, taking into account the relevant economic theories how MNO-MVNO relationship should be dealt with in Turkey needs to be studied. Without sufficient attention to this issue, it is unlikely to conduct a healthy assessment about the problems due to the MNO-MVNO relationship.

The primary aim of this paper is, depending on the theoretical and empirical research, to examine whether the Turkish regulator should mandate MNOs to provide wholesale access for MVNOs or leave it to the voluntary agreements between the parties. In other terms, should MNO-MVNO relationship be regulated or not? In addition to theoretical and empirical research; relying on Cournot competition and a linear demand function, the market conditions to come to a voluntary agreement between 3 active MNOs and a number of MVNOs in Turkey are assessed. It is proposed that the Turkish regulator shouldn't deal with the MNO-MVNO relationship for now and continue to monitor the market forces for a while at least until one of the parties apply to the regulator for a dispute resolution. But, even if one of the parties comes with such an argument, before imposing an obligation on MNOs, the regulator should assess whether the market is sufficiently competitive. Should the market forces are working properly; there is no reason for regulatory intervention even if there are no contractual relationships between MNOs and MVNOs.

The remainder of this paper proceeds as follows. In chapter 2, whether MVNOs are needed for more competition is discussed. In chapter 3, the issue whether MNO-MVNO relationship be regulated or left to voluntary agreements between the parties is examined. After obtaining the theoretical and economic background in chapters 2 and 3, chapter 4 focuses on empirical research based on the different regulatory approaches in different jurisdictions. In chapter 5, the necessary information about Turkish mobile market is provided to assess the MNO-MVNO relationship. And in chapter 6, an analysis is carried out based on the observations from economic papers and empirical research to assess whether the Turkish regulator should intervene in the MNO-MVNO relationship or leave it to the commercial agreements between the parties from economics point of view. And finally, chapter 7 provides some concluding remarks.

## 2. Are MVNOs needed for more competitive mobile telecommunications sector?

Before discussing whether MVNOs are needed for more competition in mobile telecom markets, it is considered that first reviewing the objectives of regulations and competition policies in general terms and then defining MVNOs might give an insight about the issue. After that the main issue whether MVNOs might help improving the competition is discussed.

### 2.1. Brief review of the objectives of regulations and competition policies

Almost all people should be familiar with the regulation as anyone who wants to travel from one place to another by public transportation has to abide by the rules set by authorities; as anyone who wants to travel by private car has to abide by the traffic rules; as anyone who earns some money has to pay some taxes; and as anyone who wants to build a house has to get the necessary permissions from the relevant authorities.

But from economics point of view Viscusi (2005, p.357) defines "economic regulation" as "*government imposed restrictions on firm decisions over price, quantity, and entry and exit*". He also explores the rationale behind regulation and discusses the different approaches behind the government intervention into the industries. According to Normative Analysis as a Positive Theory (NPT) "*regulation is supplied in response to the public's demand for the correction of a market failure"*; and capture theory states that "*regulation is supplied either in response to the industry's demand for regulation or the regulatory agency comes to be controlled by the industry over time"*. But the economic theory of Regulation argues that *"regulation is supplied in response to the demands of interest groups acting to maximize their income"* (See Viscusi, 2005, p.375-89 for detailed analysis of these theories).

On the other hand, Melody (2001, p.13) argues that the most fundamental objective of public utility regulation is ensuring everyone has access to a service at reasonable prices. Melody divides the objective of regulation into two components as economic and social objectives. From economic perspective the services should satisfy the consumer demand and be supplied efficiently. From social perspective, the service should be supplied to everyone that demands these services on reasonable terms, even if it is unprofitable for the supplier to supply the services.

To sum up, although some of them seem related to each other the objectives of regulation can be counted as lower prices; higher quality goods and services; protection of consumer interests; providing universal services to all citizens; development of the relevant sector and ensuring incentives for investment; improving economic efficiency which includes removing market failures such as abuse of market power or externalities and thus maximizing welfare;

and creating a sustainable competition in the regulated sector either by removing barriers to entry whenever possible or making regulations to promote the level of competition. Last but not least, although economists have not put much emphasis as far as our literature review shows, removing the uncertainties about regulatory decisions should be another important objective of the regulations as it directly impacts the investment incentives of the firms. For our case these firms are MNOs and MVNOs.

Regulators, either ministries in some countries or independent regulators in most of the developed countries, regulate telecommunications industries to achieve some of these different objectives. Since frequency is a scarce resource, the regulators need to utilize this resource optimally and ensure sufficient competition. Moreover, the regulations need to stimulate the introduction of new and innovative services and protect the investment incentives of the regulated firms. One way of achieving this might be introduction of MVNOs to the mobile sector if the relationship between MNOs and MVNOs could be assessed efficiently by either market forces or by the regulators.

Although it is difficult to think regulation and competition independently as both of them interacts with each other, there are different objectives of competition policies as there are in the case of regulatory objectives. Instead of strong state intervention, by adopting competition policies countries prefer market forces act freely. One of the most important objectives of the competition policy is increasing the welfare which is also one of the fundamental objectives of the regulations. But since welfare is defined as the sum of consumer and producer surplus, Motta (2004, p.20) argues that there are different approaches on which standard should be the objective of the competition policies: although economists generally prefer that increasing the total welfare should be the objective of the competition policies, there are also other arguments which states that increasing the consumer surplus should be taken as the basis for competition policies. According to Motta, another objective of the competition policies is to defence the small firms against the anticompetitive behaviours of the larger firms. This is also consistent with the objective of the higher total welfare. But, supporting small firms doesn't mean that inefficient small firms should also be protected by the competition authorities. In addition to these economic objectives, there are other objectives of competition policies like promoting market integration in the European level, or achieving some political objectives such as creating national firms specialised in a market (Motta, 2004, p.23, 28). However, it is not deemed necessary to dive into these objectives within the scope of this study as the MNO-MVNO relationship is not related to these objectives.

## 2.2. What is an MVNO?

From the customer's point of view an MVNO is another mobile telecommunications operator. Since MVNOs design and provide services by using their own brand names and retail offers; and since they have a direct relationship with the customers, the customers may not be able to differentiate the networks on which they are served. Meanwhile, there are different approaches on the definitions of MVNOs. The European Commission (2009, p.62) defines the MVNO as *"a mobile operator, which does not have a licence to use radio spectrum, but has access to the radio infrastructure of one or more mobile operators and is able to offer services to customers using that infrastructure and its own network". The* British regulator, Ofcom (2008) defines it as "*an organisation which provides mobile telephony services to its customers, but does not have allocation of spectrum or its own wireless network".* Federal Communications Commission (FCC) defines the MVNOs as *"resellers offering service to consumers by purchasing airtime at wholesale rates from facilities-based providers and reselling it at retail prices*" (Dippon and Banerjee, 2006, p.1)".

NERA Economic Consulting (2007) defines the MVNOs as *"Companies that buy network capacity from at least one mobile network operator in order to offer their own branded mobile subscriptions and value-added services".* Another consulting firm, Detecon Consulting, adds another definition for MVNOs by stating that MVNO is *"a company that does not own a mobile spectrum license but sells mobile services under its own brand name, network code and SIM cards using a licensed mobile operator's radio network"*.

Brito and Pereira (2007) differentiates between "Service Providers" and MVNOs. They define a service provider as *"a firm that resells minutes purchased from an MNO"*, and MVNO as *"a firm that offers mobile telephony services without holding a license to use the radio-electric spectrum, and therefore without a mobile radio access network, but that issues its own branded SIM cards, has its own unique mobile network code, and operates a physical network infrastructure comprising as a minimum: (i) a mobile switching centre, (ii) a home location register, and (iii) an authentication centre. An MVNO my also have: (i) an Equipment Identity Register and associated signalling capabilities, and (ii) an Intelligent Network platform to provide its customers with its own value-added services".*

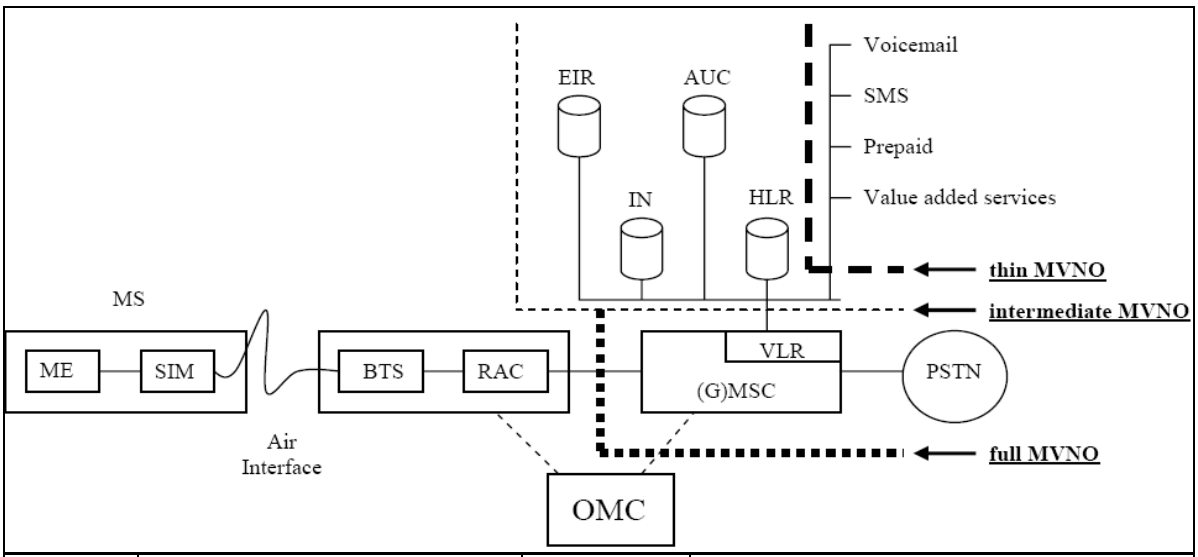
As seen from different definitions, there is no common understanding on the definition of MVNOs. But taking into account the definitions, we can see that there are some common characteristics of MVNOs:

- MVNOs do not have spectrum and need to access the spectrum and some network elements of the MNOs to provide mobile services,

- They buy network capacity or airtime from MNOs and by adding their value they resell services to the customers,
- Although the mobile infrastructure belongs to the MNOs, customers of the MVNOs can benefit from services without the awareness of the owner of mobile infrastructure.

However there is a disagreement about whether pure resellers could be classified as MVNOs or not. Some regulators see pure resellers as MVNOs, like FCC, as they purchase wholesale minutes from MNOs and resell them to the end users. On the other hand, Detecon`s and Brito and Pereira`s definitions do not include pure resellers within the scope of MVNOs because their definitions bring a SIM card requirement for MVNOs. Although pure resellers rely on the services of MNOs and they add value to the mobile services just by their brand names and marketing capabilities, the other types of MVNOs can develop and provide their own services independently from MNOs. Since pure resellers completely depend on the MNOs to provide services and they can use only their brand names and marketing advantages, pure resellers could be excluded from the definition of MVNOs.

Even if we exclude pure resellers from the definition of MVNOs, there are still some important differences between the networks of different MVNO models. To make clearer the difference between various types of MVNOs we can benefit from the following figure.




| | | | |
|---|---|---|---|
| MS: | Mobile Station | OMC: | Operations and Maintenance Centre |
| ME: | Mobile Equipment | G(MSC): | (Gateway) Mobile Switching Centre |
| SIM: | Subscriber Identity Module | HLR: | Home Location Register |
| BSS: | Base Station Subsystem | VLR: | Visitor Location Register |
| BTS: | Base Tranceiver Station | EIR: | Equipment Identity Register |
| RAC: | Radio Access Controller | PSTN: | Public Switched Telephone Network |
| AUC: | Authorisation Centre | | |

Figure 1: Full, Intermediate and Thin MVNOs (OECD, 2007)

As seen from the figure, depending on their business models MVNOs have their own GSM[3] equipments except for the radio access network including BTSs and RACs. For example a "thin MVNO" that provides voicemail, short message services, prepaid services and value added services has its own service platform. An "Intermediate MVNO" owns an IN platform, HLR, AUC and EIR, which means that this MVNO can develop its own services and make subscriptions to the networks that it controls. A "Full MVNO" has all of the necessary network components to operate a GSM network except for BTSs and RACs and it can also make interconnection agreements with other network operators without needing to the host MNOs.

Having defined and discussed the different types of MVNOs, we can discuss whether they are expected to promote competition and thus contribute to welfare increase.

### 2.3. Are MVNOs needed for more competition?

As discussed in section 2.1., since one of the most important objectives of regulations and competition policies from economics point of view is increasing the welfare, regulators need to asses the welfare effects of introducing MVNOs before allowing them to enter the market. Motta (2004, p.51) argues that although larger number of firms increase consumer surplus, when firms have to incur fixed costs which give rise to scale economies larger number of firms may not result in higher total welfare. Because higher number of competitors entails duplication of fixed costs which results in a loss of productive efficiency. So, to understand the net effect of introducing MVNOs, it is needed to compare the benefits gained from allocative efficiency and lost from productive inefficiency.

The services provided by MNOs and MVNOs can be considered as either homogenous or differentiated goods[4] depending on the business models of the MVNOs. Although this distinction affects the accommodation incentives of the MNOs as discussed in chapter 3, for now, to make an assessment about the expected effects of MVNOs we assume that the services provided by both MNOs and MVNOs are homogenous goods. Applying Cournot competition for a homogenous good industry in which;

- the cost function is given by $C = c.q + F$, where "C" is the total cost, "c" is the marginal cost but assumed to be "0", and "F" is the fixed cost of the MNOs, and
- inverse demand function is given by $p = a - bQ$, where "p" is the market price, "a" is the constant and "Q" is the total output,

[3] This figure shows a GSM network but MVNO business models can also be applicable to UMTS networks.
[4] For example, if an MVNO targets only certain customer segments such as ethnic groups, its services can be perceived as differentiated from host MNO`s services. But if it targets the whole population and provides the similar services as its host MNO, the services provided by both of the MVNO and its host MNO can be perceived as homogenous goods.

we can find that consumer surplus increases unambiguously with the larger number of firms. Because, equilibrium quantity can be found as;

(1) $q^e = \frac{A}{b(n+1)}$, and equilibrium price can be found as, (2) $p^e = \frac{A}{(n+1)}$.

From these two equations we can see that if the number of firms increases aggregate output increases and equilibrium price decreases which means that consumer surplus increases. For the above cost and demand function; the individual firm's profit can be found as,

(3) $\prod_{MNO} = \frac{A^2}{b(n+1)^2} - F_{MNO}$, and the producer surplus for "n" firms can be found as,

(4) $PS_{MNO} = n.\frac{A^2}{b(n+1)^2} - n.F_{MNO}$, which means that producer surplus decreases with the fixed costs of larger number of symmetric firms as the first term on the right hand side of the equation become smaller and the negative term becomes larger with an increase in "n".

But, taking into account the different definitions of MVNOs, which do not need to invest for complete network as MNOs, we can assume that the fixed costs that MVNOs have to incur is less than that of MNOs $(F_{MNO} > F_{MVNO})$. This means that, if MVNOs are allowed to operate, producer surplus do not decrease directly by the factor "$n.F_{MNO}$", instead it decreases by the factor "$n.F_{MVNO}$". In other words, expected decrease in producer surplus because of the multiple fixed costs should be lower if the increase in the number of firms is due to the MVNOs rather than symmetric MNOs. Consequently, it is needed to compare the gains from consumer surplus and losses from producer surplus in Cournot competition to see the net effect of introducing MVNOs on total welfare.

On the other hand, since MVNOs enter the market after MNOs they can observe the demand for MNOs` products and output. For this reason a Stackelberg competition model can also be applied to assess the welfare effects of introducing MVNOs in a mobile market. In this case, MNOs can be assumed as Stackelberg leaders and MVNOs followers. Mukherjee (2005, p.1) examined the welfare effects of new entrants in a Stackelberg competition model using general demand function and found that entry increases welfare always under some conditions. These conditions are explained below by applying the Mukherjee`s model for the MNO-MVNO case.

As discussed above, the MNOs` and MVNOs` services can be assumed as homogenous goods. Based on this assumption, to analyse the impact of MVNOs on welfare we can also assume apart from the marginal costs that the MVNOs are exactly as efficient as the MNOs are. Thus, if the marginal cost of providing the services for MNOs is "$C_i$", the marginal cost of

providing the same services for MVNOs is higher than "$C_i$" because of the wholesale prices that MVNOs have to pay MNOs and switching costs that each customer has to pay for switching from MNOs to MVNOs. If sum of these costs is $''s'' > O$, the MVNOs marginal cost increases by the factor "s" and become greater than "$C_i$" ($C_i + s = C > C_i$). Assuming for simplicity that there is no other cost of providing services, the effects of entry can be compared with and without entry using the following figure.

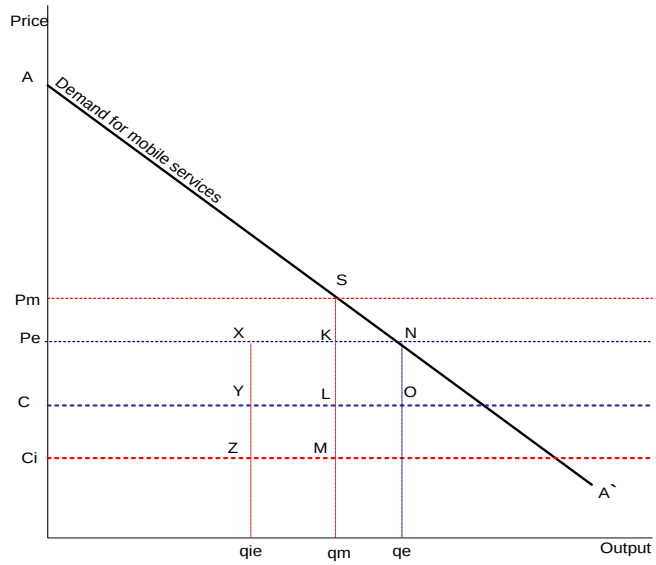



Figure 2: Conditions for welfare improving entry of MVNOs
(Adapted from Mukherjee, 2005)

If the demand for mobile services is "AA`" and MNOs output is "qm", the market price under no-entry will be "pm". If "ci" is the marginal cost of the MNOs, the area "$AC_iMS$" shows total welfare under no-entry. But if MVNOs enter the market, which have a higher marginal cost "C" because of switching and input costs, the entry results in a higher output as shown by "qe" and the price decrease to "pe". If the incumbent switches its output to "qie", which is either on the left or right hand side of "qm" but certainly on the left of "qe", the output of the MVNOs will be "qe − qie". Therefore, total welfare under the entry of MVNOs can be shown by the sum of the areas "ACON" and "$CC_iZY$". The area "$CC_iZY$" corresponds to the welfare area due to lower marginal cost and output of MNOs post-entry. Thus, the area "$ACiZYON$" shows total welfare under the entry of MVNOs. Thus, if the area "SLON" is greater than the area "YZML" the entry of MVNOs increases welfare comparing to no-entry. Other things being equal, the lower the marginal cost of MVNOs (C in the figure) the higher the welfare effect of entry. Moreover, if "$qie \geq qm$" which means that incumbent produces more comparing to no-entry condition, the area "YZML" that shows the welfare loss from introducing MVNOs disappears and welfare increases always.

Apart from theoretical studies, there is empirical research about the impact of MVNOs on the mobile sector. Kim and Seol (2007, p.295-296) analyzed the economic effects of MVNOs if introduced into the Korean mobile telecommunications market. In order to conduct their analysis Kim and Seol used actual data such as the number of subscribers, traffic volume, rate, access charge, price elasticity, and assumed that there are three stages in the entry of MVNOs into a market. In the first stage the regulator makes a decision about the type of MVNO policy that regulatory obligation is only on the dominant operators or on all operators. After monitoring the regulatory approach the MVNOs enter the market at stage two and price competition between MVNOs and the incumbent MNOs starts. As a result "service-based competition" between MNOs and MVNOs is expected to reduce the end user tariffs because the incumbents also decrease their prices to protect their market shares. In the third stage customers chose either the incumbents or new entrant MVNOs. These actions of competitors result in higher consumer surplus because the lower the prices the more consumers are expected to get the service. The lower prices are expected to create another effect: lower prices increase demand for calls and consumers make longer calls which also increases consumer surplus.

Taking into account these theoretical and empirical studies we can conclude that introducing MVNOs into a mobile telecommunications market increases allocative efficiency but to make an inference about productive efficiency it is needed to observe the cost functions of MVNOs which however are essentially determined by s which depends on what the MNOs charge for access price. Although allowing MVNOs to operate in mobile markets serves to achieve some of the objectives of regulation and competition policies, whether MNOs might grant access voluntarily to MVNOs, or whether they should be obliged or not to open their networks for MVNOs is another issue and discussed in the next chapter.

## 3. Should MNO - MVNO relationship be regulated or left to the voluntary agreements between the parties?

### 3.1. Economic analyses related to the incentives of MNOs to provide access to their networks

Although MVNOs are expected to stimulate competition which results in lower prices and higher consumer welfare, some countries preferred to mandate MNOs to open their networks for MVNO access, and some others leave it to the commercial agreements between the parties. The fact that the MNOs are obliged to provide wholesale access to MVNOs in some countries but not in others brings about the issue whether MNO-MVNO relationship should be regulated or not for more effective competition.

There might be different economic approaches on the assessment of the relationship between MNOs and MVNOs, but one could state that MVNOs are competitors in downstream markets and MNOs are competitors in both upstream and downstream markets. In other words, MNOs are competing in the downstream market by providing services to end users, and they are also competing in the upstream market with other MNOs by providing wholesale access to the MVNOs. Thus, MNOs are vertically integrated companies. Since there are 3-5 MNOs competing in each country, these MNOs might have an incentive to refuse the MVNO access or to accept MVNOs depending on the costs and benefits for them. For example, if a relationship between an MNO and MVNO is established, then MNOs can benefit from this relationship by getting wholesale rents, or by reaching more customer base (because MVNOs target new customers, etc.). But MNOs may also have an incentive to refuse the access because in the absence of the MVNOs, the market would be shared only among the competing MNOs.

So, as discussed in chapter 2, given the positive contributions of MVNOs to the market, the regulators need to find an answer for the question whether MNO-MVNO relationship should be regulated or not. However, since one of the main preconditions for regulatory intervention in an industry is market failure, to intervene in the relationship between MNOs and MVNOs the regulators need to justify that the market forces are not working properly. Moreover, since most of the times regulators do not have sufficient information about the costs of the operators obliging MNOs to open their networks may result in other inefficient outcomes. In the following figure the effects of setting either low or high prices on welfare is illustrated. In this figure the MVNOs are customers and MNOs are producers. Assuming that MNOs are the access providers and MVNOs are the access seekers, the market price for access can be found as the intersection of demand and marginal cost of providing the access to the MNOs` networks.

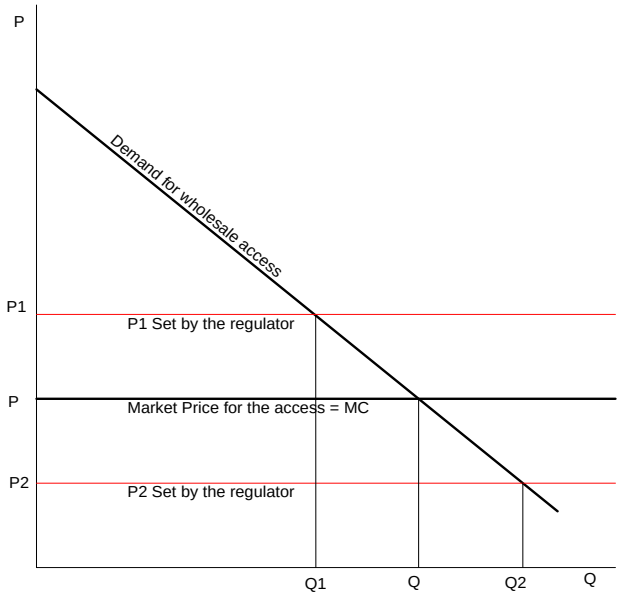


Figure 3: Welfare impacts of setting low or high access prices

In this case, the market price will be "P" and market output will be "Q". But if prices are set too high either by regulation or by unregulated market forces, the output will be "Q1" which means that some of the MVNOs will not be able to sign wholesale agreements. If prices are set too low, the demand for wholesale agreements will be high but in this case investment incentives of the MNOs might be reduced because there might be a danger that MNOs can not get the return on their investments. But, as discussed in the following paragraphs, if MVNOs offer more benefits than costs to the MNOs then it is almost certain that MNOs will open their networks to MVNOs voluntarily. When assessing the necessity of the regulatory intervention to the MNO-MVNO relationship it is worth bearing in mind that although Virgin Mobile is cited as the most successful global MVNO, there is no access obligation for MNOs in most, if not all, of the countries that Virgin Mobile operates[5].

According to one of the industry analysts, Ovum Consulting (2001), there are some opposing views on whether a MNO-MVNO relationship should be regulated or not. The supporters of regulatory intervention claim that MVNOs lead to more service competition and without regulatory support MVNOs can not enter the market or compete for the long term, because it is expected that in the long term MNOs will raise wholesale prices to drive MVNOs out of the market and take full end user revenues. The other group, which finds regulation unnecessary, claim that four or five MNOs in each country is enough for strong service competition and regulated supply to MVNOs is likely to reduce investment: because there is

[5] Virgin Mobile operates in Australia, Canada, France, India, South Africa, UK and US. Although we do not know the situation in India and South Africa, there are no access obligations for MNOs in the other countries. In France, the French regulator ARCEP imposed the obligation for three mobile operators to provide wholesale access for MVNOs, but the decision was vetoed by the European Commission and hence there is no access obligation for MNOs.

a danger that regulators might set wholesale prices too low and incentives for investment then switch from infrastructure based competition to service based competition. This point gains importance because it is generally accepted that infrastructure based competition is needed for sustainability of competition in the long run.

It is argued by KPMG[6] (2006) that although the incumbents, being the pioneers, invested in massive amounts of money into spectrum and network infrastructure, it is almost impossible for them to be able to penetrate all market niches and they need to reach mass consumer adoption to earn the necessary return on their capital. One way of earning money might be cooperating with MVNOs because MVNOs come out with different business models and may increase the customer base of MNOs. For example, MVNOs might target ethnic groups and may reach these groups more easily than MNOs. And retailers, like TESCO or ASDA, can also extend their existing core brands to the telecommunications sector by acting as MVNOs and these retailers can reach more easily their customers than national MNOs. Although the customers of MVNOs are not the customers of MNOs, MNOs benefit from the cash flows by obtaining wholesale rents from MVNOs.

In Brito and Pereira (2008) it is emphasized that in oligopolistic industries the oligopolistic firms have different incentives than vertically integrated monopolists to open their bottleneck facilities to the new entrants. Because, even if one of the incumbents denies access, there is no guarantee that the entrant will be foreclosed as the entrant is likely to sign an agreement with the other incumbents. Another reason for this view is that, the revenue loss from the downstream market because of the entry is not incurred by only the access providing incumbent but the other incumbents also incur the loss from the downstream market. However, only the access providing incumbent gets the wholesale rent from the entrant.

Banerjee and Dippon (2009) when discussing whether MVNO access should be mandated for MNOs, they noted that two points could be made. First, despite strong retail competition in the mobile sector in almost all jurisdictions, competition at the wholesale is limited in most of the countries. In the absence of the wholesale competition entry by MVNOs is likely to be impeded and therefore they may require help from regulation. Second, in some instances there may be wholesale competition, and in these cases the large-scale emergence of voluntary MNO–MVNO partnerships around the world casts doubt on views that entry-facilitating regulatory intervention is needed.

According to Dippon (2006) unjustified regulation may lead to allocative inefficiency (regulation may distort price-cost relationship), dynamic inefficiency (regulation may

[6] KPMG is a global audit, tax and advisory services company. For more information, see, http://www.kpmg.com.

discourage investment and innovation and investment by MNOs and MVNOs), and may have detrimental effect on overall social welfare. And if MVNOs know that regulation will help them, unnecessary regulation may stimulate the opportunistic behaviour of MVNOs. Banerjee and Dippon (2009) argues that when voluntary MNO–MVNO relationships do not form because of insufficient conditions to come to an agreement, no economic welfare gain can accrue from forcing such relationships to exist. They demonstrated that, an MNO`s strategy to voluntarily provide wholesale access to an MVNO is justified by the net economic benefits produced. In particular it was argued that the two key factors in that relationship are;

- the value of the MVNO's brand reputation, and
- the level of the wholesale discount in the transaction between the MNOs and MVNOs.

On the other hand, Banerjee and Dippon suggested that;

- The default regulatory policy should be to encourage the voluntary formation of MNO–MVNO relationships. If the prerequisites exist in the market for such relationships (such as the availability of wholesale mobile access or an effectively competitive mobile retail market), then there is no need for regulatory intervention, even if some or all of the MVNOs are unable to privately reach agreement with existing MNOs.
- If regulators could prove that there is a market failure (e.g., due to monopoly control or denial of wholesale access) then regulatory intervention can be justified as a way to facilitate entry by the MVNOs. If neither the "wholesale access market" nor "the retail market" for mobile services is competitive, for example, because of the market power (the case might be individual or collectively dominance case), then antitrust or competition enforcement policies should tackle the problem directly and hence again there is no reason for regulation addressing the MNO-MVNO relationship.

Although Banerjee and Dippon emphasized that an effectively competitive mobile retail market is a prerequisite to establish a voluntary relationship between MNOs and MVNOs, if MVNOs could observe fierce competition in the mobile retail market they may not expect any benefit from entry or fear from loss in the market and thus they may not have an incentive to enter the market at all.

According to Ulset (2002, p.538); Ofcom (the former Oftel) and Norwegian Department of Communication reached the conclusion that the positive effects of MVNOs are highly uncertain and not big high enough to justify regulatory intervention. One of the main reasons for such scepticism might be the expected negative incentive effects that such a regulation would have on investment of MNOs in future networks. Although it is accepted that such regulation will lead to service innovations and competition in the market, most incumbents and some regulators expect positive effects to be outweighed by negative ones.

To analyse the likely behaviour of MNOs towards the entry of MVNOs Dewenter and Haucap (2006, p.1, 12) studied on the "incentives of MNOs to open voluntarily their networks to MVNOs". They took into account different models of competition. They show that, the MNOs' incentives to voluntarily provide network access critically depends on "the model of competition" and, "the degree of product differentiation". They rely on the point that if the services offered by the MVNOs are sufficiently differentiated, the revenue effects are expected to outweigh the competition effects and in this case MNOs will voluntarily provide network access. They find that;

- Under Cournot competition, MNOs are always expected to invite MVNOs onto their network, if the market is sufficiently large.
- But, under Bertrand and Stackelberg competition voluntary MVNO access is expected to be granted if the services offered by MVNOs are sufficiently differentiated.

Since, to our knowledge, there is no monopolistic mobile market in any country examining the MNO-MVNO relationship requires taking into account the existence of more than one potential access providers. In fact it means that wholesale mobile markets in each country are competitive to some degree. Ordover and Shaffer (2007) focuses on whether and on what conditions will an access-seeker be provided with access to a necessary input in a market in which multiple potential access providers compete with each other in upstream and downstream markets. Although their study doesn't address the MNO-MVNO relationship directly, it might shed a light on whether the MNOs are expected to provide access for MVNOs without regulatory interventions.

Ordover and Shaffer (2007) seek an answer to the questions of why some incumbents are willing to supply inputs to (potential) competitors, while others are not. Hence they seek to determine the main factors for an incumbent to wish supply an access-seeker. It is expected that, as noted by Ordover and Shaffer, if there are no wholesale transactions between access providers and access-seekers in a competitive wholesale market, the main reasons are either the access providers have capacity constraints, or regulators do not allow the access-seekers to enter, or potential providers are colluding tacitly to block the entry. But Ordover and Shaffer find that the provision of access by the incumbents in market conditions where there are no capacity constraints, no regulatory impediments, and no possibility for collusion depends on whether the firms' inputs are homogeneous or differentiated, whether diversion to the entrant's product impacts incumbent firms proportionally[7] or differentially[8], and whether the entrant can commit to the positioning of its product ex-ante.

[7] Proportional impact of the entrant (proportional cannibalization) means that sales of the entrant's product cannibalize sales of the incumbents' products in proportion to the incumbents' pre-entry baseline shares. For

According to their studies;

- the entrant is more likely to be supplied by the incumbents when the incumbents' inputs are homogeneous. But if their products are differentiated the dominant strategy is not to supply the entrant at all. (To see why it is, refer to the footnotes 7 and 8).
- if the entrants` product cannibalizes the incumbents' products proportionally, the incumbents are expected to compete to supply the entrant and this competition ensures the entrant to obtain access. But, if the cannibalization effect is disproportionate and hurt the incumbents` revenue, the entrant is not supplied in equilibrium.
- if the entrant cannot commit to its positioning strategy before receiving the incumbents' offers the entrant is less likely to obtain access. For example, contracts that contain non-compete obligations[9] for the entrant is likely to improve market performance and lead to an entrant being supplied when it would not otherwise be. Because by means of non-compete agreements the entrant commits to the positioning of its product ex-ante, and makes it more attractive to be supplied by the potential access provider.

In Bourreau *et al.* (2007), there are two vertically integrated firms which produce the intermediate good for downstream competitors and active in downstream markets and a pure downstream firm which uses the inputs from upstream firms and compete with the upstream firms in the downstream market. Although the inputs for the downstream market are homogenous, the downstream products are differentiated and all of the firms compete in downstream market in a Bertrand like fashion. Bourreau *et al.* find that the degree of differentiation between firms in the downstream market is likely to affect the outcome in the wholesale market and if the downstream market is differentiated sufficiently, then the upstream markets are expected to offer wholesale access for the downstream firms. Considering the MNO-MVNO relationship, if MVNOs target niche markets like ethnic groups, then it can be assumed that the MNOs` and MVNOs` services in the downstream market is highly differentiated which creates an incentive for MNOs to open their networks voluntarily.

In Bijlsma *et al.* (2008), there are “m” number of incumbents which have infrastructure, and “n” number of service based firms which needs to access to the infrastructure of the incumbents in an unregulated market. When the service-based firms supply homogenous

example, if there are two incumbents, incumbent 1 and incumbent 2, with market shares 40% and 60% respectively and the entrant captures 10% after the entry, proportional impact implies that 40% of the entrants customer will come from the first incumbent and 60% of them from the second incumbent.

[8] Differential impact of the entrant (own-supplier cannibalization) means that the sales of the entrant’s product cannibalize the sales of the incumbents who supplies the entrant, because it is assumed that the inputs of the incumbents are differentiated and depending on this the outputs are also differentiated and the entrants sales can only affect the supplier’s sales. For example, if there are two incumbents, incumbent 1 and 2, with market shares 40% and 60% respectively and the entrant captures 10% after the entry, differential impact implies that all of the entrant`s customers will come from the first incumbent and this incumbent’s share will decrease to 30%.

[9] The entrant promises not to compete for the supplying incumbent's customers.

services, the incumbent forecloses service-based firms only if there is no other infrastructure based firms present in the market. But, when service-based firms supply differentiated services, the incumbents never forecloses the downstream competitors from the market.

Taking into account all of these economic analyses focusing on the incentives of access providers to provide wholesale access to the new entrants in oligopolistic markets, it can be concluded that it is almost common outcome in all analyses that if downstream competitors differentiate their services, upstream firms are expected to open their networks voluntarily. In other words, if MVNOs are expected to differentiate their services from potential host MNOs, then it is more likely that MNOs will offer wholesale access to the MVNOs. However, there are some cases that MNOs are likely to impede the entry of MVNOs such as by way of colluding tacitly with other MNOs. If regulators establish that the entry of MVNOs is deterred, not as a side effect of the competitive behaviour by the incumbent firms but because of the market failure, then they might impose on the MNOs to open their networks to MVNOs. If regulators decide that such an obligation should be imposed, then two important problems arise. One is, to whom such an obligation should be imposed and the other is what should be the terms of obligation, and most importantly, what should be the access price for the essential input? Although focusing on these questions is not the primary aim of this study, after concluding that regulatory intervention is needed to establish an MNO-MVNO relationship these issues gain importance and hence the following two-subsections are reserved for these questions.

### 3.2. If needed to intervene who should be obliged to open their networks?

As discussed above the main prerequisite for intervention in a market is market failure which is likely to arise from the possession of market power[10] by one or more firms. Despite the willingness of MVNOs to enter the market if there is no MVNO, in the absence of legal entry barriers and capacity constraints, the absence of MVNOs could be related to the existence of joint dominance or tacit collusion between the MNOs[11] rather than single dominance of an MNO. Having established that market is not functioning properly, the regulators need to asses which operator or operators would be obliged to open their networks.

Kim and Seol`s (2007) analysis for Korean market touches on this issue and they examine the effects of obliging only the dominant MNOs or all MNOs to provide MVNO access. Their

[10] Economic theory defines market power as the ability of one or more firms to raise prices profitably above the competitive level. OFT (2004) defines the market power as "the ability profitably to sustain prices above competitive levels or to restrict output".

[11] To claim that the MNOs are colluding to prevent entry, the regulators need to justify that MNOs have incentive to coordinate, ability to coordinate and ability to punish the deviator.

analysis based on the assumption that the MVNOs will occupy a 3% market share in a year, MNOs will reduce prices by 10% in response to the entry of MVNOs, and the charge difference between the MNOs and MVNOs will be 10%. Based on these assumptions, Kim and Seol`s analysis produced that if all MNOs are obliged to provide wholesale access the change in the consumer surplus is expected to increase about 2 times more comparing to the increase in consumer surplus in the case of obliging only the dominant MNOs. But, producer surplus is expected to decrease more than 2 times comparing to the decrease in producer surplus when obligations are imposed only on dominant MNOs. As a result, the gains from consumer surplus is expected to be higher than the loss from producer surplus and the social welfare is expected to increase independently from the adoption of the policy which obliges either all MNOs or only dominant ones.

In the EU, the Access Directive[12] serves as a framework for regulating the wholesale access in the context of the telecommunications sector for member states. Access regulation is designed to increase service based competition by enabling the service-based companies to enter the market without investing too much money for the infrastructure but by using the infrastructure of facility-based firms. According to this Directive, national regulatory authorities may impose obligations on operators to meet reasonable access requests to specific network elements if the regulators consider that denial of access would hinder the emergence of a sustainable competitive market at the retail level. So the regulators need to assess which operator or operators should be obliged to open their networks based on the decision that regulatory intervention is needed for the MVNO access.

The answer to the question “Which operators should be obliged?” can be found in the Commission guidelines on market analysis and the assessment of significant market power (2002)[13]. According to this Guidelines, national regulators have jurisdiction to intervene and impose obligations on dominant operators if markets are considered not to be effectively competitive. In other words the Commission Guidelines addresses the dominant firms to be regulated if market forces do not function properly. So, assuming that MVNOs are deterred from entering the market as a result of the anticompetitive behaviour of the incumbents, one of the remedies might be obliging only dominant operators to open their networks for MVNOs. But, if regulators could manage to justify that the deterrence of MVNOs` entry is the consequence of tacit coordination, obliging all of the MNOs to open their networks seems another reasonable remedy to facilitate the MVNO entry.

[12] European Commission, (2002), Directive 2002/19/EC of The European Parliament and of the Council of 7 March 2002 on access to, and interconnection of, electronic communications networks and associated facilities.
[13] European Commission, (2002), Commission guidelines on market analysis and the assessment of significant market power under the Community regulatory framework for electronic communications networks and services.

### 3.3. If regulatory intervention is justified, how should the access price be determined?

Even if regulators justify that some of the operators should be obliged to open their networks, then the issue what the terms of obligations should be needs to be examined by the regulators. But, it seems that the determination of the access price forms the most critical point for regulators as it impacts both the investment incentives of MNOs and entry and investment incentives of MVNOs. Put another way, the regulators need to establish a balance between the protection of investment and entry incentives of MNOs and MVNOs. The aim of this paper is not how to determine the access prices, but rather whether the relationship between MNOs and MVNOs should be regulated or not. However, it might be useful to touch on this issue in this sub-section because the next step, after deciding that the MNOs should be regulated and only the dominant MNOs or all of them should be obliged to open their networks, should be determining the access price.

To impose regulations for MNOs it is also needed to justify that MNOs` networks are essential facilities for MVNOs. Although there is no universal definition of essential facility (For example a power station can be an essential facility in a small market but may not be in the national context) according to Dewenter and Haucap (2007, p.6) a facility can be considered essential if downstream competitors can not provide services without access to it. If downstream competitors need access to the incumbents' bottleneck or essential facilities to be able to compete with incumbents but the incumbents services do not depend on the downstream competitors facilities this type of access is considered as one-way access (Armstrong, 2001; Vogelsang, 2005). For example, the access of an MVNO such as TESCO mobile to one of the MNO`s facilities such as O2`s network might be an example for one-way access. On the other hand two-way access describes a situation where two facility-based competitors such as two MNOs grant access to each others essential facilities. For example, access of O2 to Vodafone`s network and vice-versa might be an example for two-way access which is also known as interconnection.

Thus, MNO-MVNO relationship falls within the scope of one-way access. As briefly noted in the 2`nd chapter, one of the objectives of the regulation is increasing economic efficiency[14]. According to Armstrong (2001) when determining the access price if economic efficiency is the main concern, it is necessary to consider the incumbents` retail prices and access charges simultaneously, because it allows the trade-off between allocative efficiency and productive efficiency to be considered correctly. By welfare maximization purposes, the best

[14] Economic efficiency includes allocative efficiency, productive efficiency and dynamic efficiency.

approach for setting the regulated retail prices and access prices simultaneously is Ramsey Pricing[15]. But since our concern is, assuming regulatory intervention is justified, how access price for MVNOs should be set we do not care about how incumbents` retail price have been set. The incumbents have already been providing services before the MVNO`s entry means that the incumbents` retail prices are known and for that reason it is difficult to apply the Ramsey pricing to find efficient access prices.

Given the incumbents retail prices, another approach to set the access prices might be Efficient Component Pricing Rule (ECPR) which states that access price of an input should be equal to the direct cost of supplying this input plus the opportunity cost to the incumbent which supplies this input. The ECPR can be expressed formally as;

$$A = C_i + \sigma.(P_i - C_d)$$

where, "A" is the access price that MVNOs need to pay to MNOs, "Ci" is the marginal cost of providing access to the MVNOs, "Cd" is the incumbent`s marginal cost of providing the downstream service, "Pi" is the retail price that incumbents charge to end customers, and the parameter "$\sigma$" measures how many units of incumbent`s retail service are lost as a consequence of supplying a unit of access to downstream rivals, that is MVNOs. In fact, the term $\sigma.(P_i - C_d)$ corresponds to the incumbent`s lost profit because of granting access to the MVNOs or the MNO`s opportunity cost of providing the mobile access (Armstrong, 2001; Cave and Prosperetti, 2001).

Using the stylized version of Figure 1 we can explain how ECPR can be applied for MVNO access to the MNOs` networks.

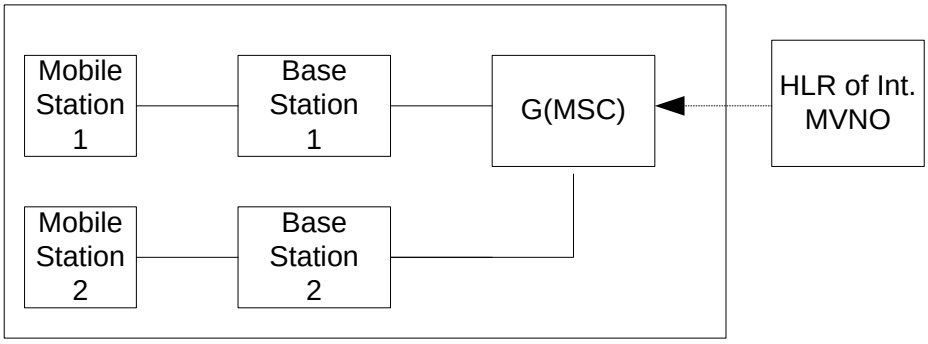



Figure 4: MVNO access to an MNO`s network

Assuming that the incumbent MNO`s retail price for calling from mobile station 1 to 2 is £50p, marginal cost of providing this service from "Mobile Station 1" to G(MSC) is £15p, and from G(MSC) to "Mobile Station 2" is £15p, and marginal cost of providing MVNO access to the

[15] For more information about Ramsey pricing see Armstrong (2001); Vogelsang (2005).

incumbent MNO`s G(MSC) is £10p; access price for the MVNO for 1 unit call could be found as; A= 10+[50-(15+15)]=£30p. Given £30p access price that MVNO should pay MNO, and £50p retail price of MNO, then MVNO will be able to offer services if its other costs is below £20p. Otherwise, retail prices of MVNO will be higher than £50p which means that MVNO will not able to compete with MNO.

## 4. Case studies

### 4.1. An overview of the MVNOs` position in mobile markets

MVNOs have been seen in a number of markets from the beginning of 2000s and penetrated to the most of the markets today. The figures below show their numbers and market shares in some mobile markets. Although there are many MVNOs, their market shares are observed to be very small. The high market shares in Germany and the UK markets is mainly due to the pure resellers` market shares (Ofcom, 2008), but as discussed in Chapter 2, some authorities do not see pure resellers as MVNOs as they only resell the MNOs` services without adding any value except for their marketing capabilities.

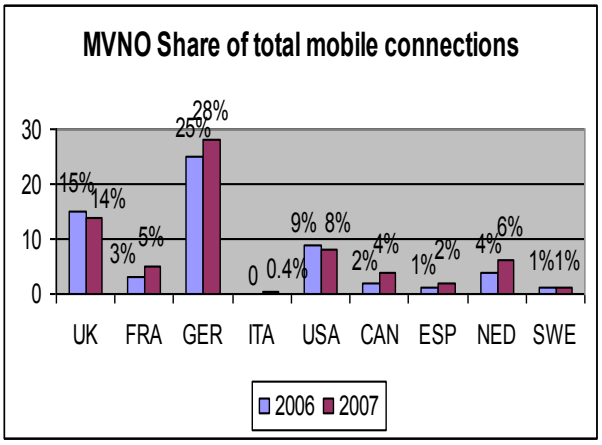



Figure 5(a): Market shares of MVNOs in some countries (Ofcom, 2008)

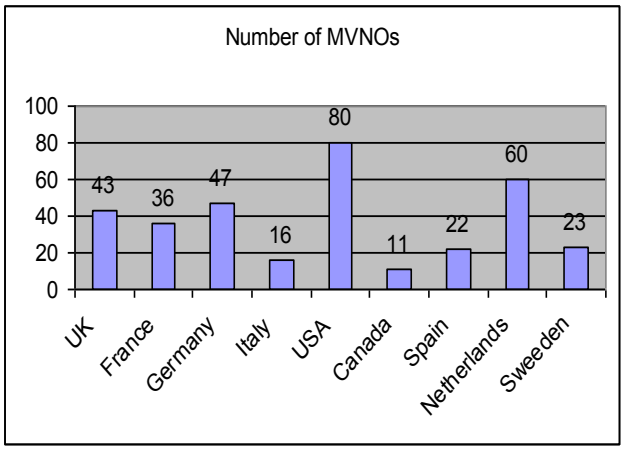



Figure 5(b): Number of MVNOs (www.telecompaper.com)

As seen from the Figure 5(a), if pure resellers are not taken into account the market shares of MVNOs will be seen as very small in the selected mobile markets. Although there is no regulatory support for MVNOs today, the number of MVNOs is the highest in the USA. The competitive effects of MVNOs are discussed in the Analysis and Discussion section.

### 4.2. Regulatory approaches towards MNO-MVNO relationships

Regulatory approaches towards MVNOs differ among different jurisdictions. Although some countries have regulated the MNO-MVNO relationships, like Spain, Slovenia[16] and Japan, some others have not intervened this relationship. Moreover although some European regulators have attempted to regulate, for example the French and Irish regulators, these regulatory approaches have been vetoed by European Commission which has the power to veto the proposals of regulators of Member States. The different approaches of the regulators to the issue are discussed below relying on two-selected countries for each case.

[16] Information about the Slovenian approach come from "Dippon, C., NERA Economic Consulting, e-mail message to Beytullah.Kuscu.1@city.ac.uk, 20.03.2009".

### 4.2.1. Regulated MNO-MVNO relationships

#### 4.2.1.1. Spain

Although initially there were three MNOs; Telefonica, Vodafone and Orange, with market shares of 45%, 31% and 24% respectively in 2005 (NERA, 2007) when the Spanish Telecommunications Market Commission (TMC) dealt with the MNO-MVNO relationship, today there are four MNOs in the Spanish mobile market.

Despite being entitled to operate as MVNOs, the Spanish MVNOs were not operational as they had been unable to enter into the wholesale access agreements with MNOs by 2005. When assessing the rationale behind this, the TMC found in 2005 that the market was highly concentrated and sufficiently transparent for MNOs to coordinate their actions. Moreover, TMC considered that excessive and stable profitability reinforces the MNOs' incentive to maintain high prices, and based on this consideration it concluded that MNOs have incentive to coordinate their actions and prevent the entry of MVNOs by refusing the access to their networks. Thus, TMC found in 2005 that three MNOs in Spain hold a joint dominant position in market for "access and call origination on public telephone networks". According to the TMC this dominant position was a threat for the development of fixed-mobile convergent services,[17] and for the interests of consumers. Relying on these considerations it decided that the dominant operators must offer third party access to their networks. Otherwise it would intervene and impose the prices and access conditions for both parties. Since TMC`s decisions needs to be submitted to the EC before entry into force, the findings submitted to the EC and the EC endorsed the measures proposed by the regulator in 2006, but also asked it to keep the development of the market under close review. The TMC was also asked to monitor the effects of the possible entry of a fourth MNO (Xfera) in 2006 on the future sustainability of the collective dominant position (NERA, 2007).

To sum up, before intervening the relationship between MNOs and MVNOs, the TMC reviewed the market and on establishing that market forces are not working properly, it intervened the market and the EC also endorsed its findings.

#### 4.2.1.2. Japan

The three Japanese MNOs NTT-DoCoMo, au Group, and Softbank Mobile, of which market shares changed from 57% to 51%, 22% to 28% and 15% to 17% respectively from 2001 to 2007 (Ministry of Internal Affairs and Communications (MIC), 2009).

[17] The term "Fixed-Mobile Convergence" is often used to describe the technological development in the communications industry which makes it possible to provide content (audio, video, and data services) to consumers by way of integrated digital networks (fixed, mobile networks, cable platforms etc.) and integrated end user devices (mobile terminals, portable computers, etc).

In 2001, there was only one MVNO, Japan Communications Inc. (JCI), which started mobile data services using one of the MNO`s network on a commercial basis, without regulatory intervention. But, in 2002, the MIC which also functions as the telecommunications regulatory body in Japan published the MVNO guidelines to encourage entry of MVNOs into the mobile market. As the purpose of the guidelines was to promote entry of MVNOs, it did not clearly require MNOs to open their networks to MVNOs. After the publication of the guidelines, JCI wanted to provide services using third generation (3G) mobile phone networks and requested MNOs to provide access to their networks. Having seen no progress, JCI then formally requested negotiations for access to the DoCoMo`s 3G network in August 2006, but the later was not keen on for such a partnership. In 2007, the regulator decided that MNOs had to negotiate with potential MVNOs regarding their request and if they couldn't reach an agreement, MVNOs could ask for arbitration by the Dispute Settlement Committee. In July 2007, JCI requested the Committee to arbitrate their disagreement with NTT DoCoMo. The Committee`s decision required NTT DoCoMo to open her 3G network for JCI and at last, NTT DoCoMo published the network access tariffs in August 2008, and JCI started their services the same month (JCI, 2007; Shoji, 2009).

It is interesting that the Japanese regulator obliged one of the MNOs to open its network for third party access despite the existence of commercial agreements between the other MNOs and MVNOs. It might have been understandable if there had been no contract between the MNOs and MVNOs. However given such an obligation where there is no foreclosure the MVNO entry, it seems that the regulator has found DoCoMo to dominate the market and restrict competition by refusing the access.

### 4.2.2. Non-regulated MNO-MVNO relationships

#### 4.2.2.1. The UK

Today, there are 5 MNOs in the UK: Vodafone, O2, T-Mobile, Orange and 3UK. Their market shares were 23.5%, 24.7%, 24.5%, 23.8% and 3.3% respectively in 2004, but changed to 23%, 27.9%, 21.8%, 21.3% and 5.8% in 2008 (Ofcom, 2009, p.232). Although four MNOs` market shares were almost symmetric in 2004, this symmetry has been distorted in the following years, which is considered as being one of the indicators of a competitive market.

The UK is the first European country that allowed MVNOs to operate in its mobile market in 1999 with the entry of Virgin Mobile. Oftel decided in 1999 that existing legal framework provided inadequate grounds for obliging MNOs to open their networks for MVNO access, but the MNOs and MVNOs were free to come to voluntary agreements between them on commercial basis. Meanwhile, Oftel stated that it would continue to monitor the market and

emphasized that it has the power to impose obligations on MNOs if the competition in the market do not function sufficiently (Wlaam and Maitland, 2003).

Later on, in 2003, considering that the network access and call origination services provided by MNOs to MVNOs fall within the scope of *"access and call origination market on public mobile telephone networks,"* one of the 18 markets identified by the EC for ex-ante regulation; Oftel assessed the level of competition in that particular market to determine whether any particular MNO possessed dominance, which would have provided economic justification for regulatory intervention on behalf of the MVNOs. Oftel first analyzed whether any carrier had individual market power. Taking into account the market shares, costs and technologies of the MNOs, Oftel found that no MNO has a significant advantage over its competitors. Oftel then investigated whether some or all of the MNOs are collectively dominant or not. Having established that there are significant fluctuations in relative market shares of the MNOs; significant asymmetries in profitability; continuing entry of service providers onto the retail market; fluctuating relative prices; and assessing that the retailers have a countervailing buyer power; Oftel concluded that there was no collective dominance among the MNOs. As a result, Oftel found that the wholesale and retail markets were competitive as of 2003 and likely to persist in the future and hence refrained from intervening the MNO-MVNO relationship (NERA, 2007).

#### 4.2.2.2. The USA

Today, there are four national mobile telephone operators in the United States: AT&T (formerly known as Cingular Wireless), Verizon Wireless, Sprint Nextel, and T-Mobile USA; and as of year-end 2006 their market shares were 27%, 26%, 23%, and 11% respectively. Apart from these national competitors, there are regional operators and their total market share was about 13% in 2006 (FCC, 2008).

Regarding the MNO-MVNO relationship, the regulator has repeatedly found the mobile market to be effectively competitive and, thus, refrained from intervening the market. To assess the level of competition in the mobile markets FCC used a framework that indicates the level of competition in four categories: (1) market structure, (2) carrier conduct, (3) consumer behaviour, and (4) market performance. With respect to market structure, FCC found that 98% of the population has access to three or more different mobile telephone operators as of 2006, and found that none of the competitors has a dominant position. With respect to the carrier conduct, the FCC found that the MNOs have "innovative pricing plans and service offerings" which meant a sign of a competitive market for the FCC. Regarding the consumer behaviour, the FCC found that the customers have a choice to freely switch

providers with the aid of the mobile number portability in response to dissatisfaction from MNOs` cost and service quality, and thus, concluded that consumers` ability to switch between MNOs is a sign of competitive market. And, finally, taking into account the increased subscribership, increased minutes-of-use of mobile services, and increased quality of services; the FCC found that market performance is improving and competition in the mobile sector continues to increase welfare (NERA, 2007).

### 4.2.3. Other cases

#### 4.2.3.1. The Netherlands

Although there were five MNOs in the Netherlands before 2005, following the acquisition of Telfort by KPN in 2005, and of Orange by T-Mobile in late 2007; now there are three MNOs in the market. According to Jaspers *et al*. (2007), the KPN, Vodafone and T-Mobile`s market shares were 38%, 28% and 17% respectively and the other two small MNOs` (Orange and Telfort) market share was equal and 9% for each in 2005.

Jaspers *et al.* (2007) notes that based on the 1998 Telecommunications Act the dominant operators (KPN) was subject to access regulation, but with the implementation of the 2004 Telecommunications Act, the regulatory authority Opta decided that competition in the mobile market was sufficiently effective, meaning that the dominant operator KPN no longer needs to comply with access regulation. This change in the regulatory approach meant that although the relationship between MVNOs and dominant MNOs was subject to the regulatory intervention, after 2004 the entrants can only enter the mobile market through a commercial deal with an MNO. Despite not being a dominant operator, mainly because of financial problems and to utilize spare network capacity, Telfort (one of the MNOs) opened up its network to MVNOs voluntarily in 2005. Despite being one of the smallest MNOs in 2005 Telfort considered the MVNOs as wholesale customers rather than competitors and its portfolio of MVNOs were as diverse as retail chains, providers of fixed telecommunications services, charity organizations, and MVNOs focusing on international calls only. There were 22 MVNOs roaming on Telfort`s network only in 2005.

To sum up, although the Netherlands was one of the countries that intervened in the mobile wholesale access markets, on seeing sufficient competition after 2004 the regulator decided to leave market forces work freely.

#### 4.2.3.2. Ireland

There were four MNOs in Ireland: Vodafone, O2, Meteor, and “3” with approximate market shares of 43%, 33%, 20% and 4% respectively, as of year 2008 (ComReg, 2008).

As a watchdog seeing that there was no activity in the wholesale mobile market like the operation of MVNOs or resellers, ComReg decided to analyse the level of competition in the wholesale mobile market in 2004. After defining the market as *"all wholesale access and origination services provided by MNOs",* for the purpose of the analysis ComReg looked at the degree of concentration, and whether there is an incentive and ability to coordinate to impede the entry of MVNOs into the Irish mobile market (NERA, 2007). Should there be no incentive or no ability to coordinate then there is no reason to worry about the coordination in the wholesale market and any MVNO is likely to sign a contract with one of the MNOs.

Taking into account the Vodafone and O2`s 94% joint market shares of subscribers, ComReg was of the opinion that the market was highly concentrated. On the other hand ComReg examined the market shares of all market players, and established that although the market growth is non-negative, the proximity in Vodafone and O2`s shares was continuous and there was a high level of interactions between them. The level of innovations was also very limited and these innovations hadn't favour one firm over the other. And thus ComReg reached at the opinion that the players are likely to have an incentive to coordinate their actions. And finally, it assessed whether MNOs have the ability to coordinate. Considering that MNOs offer homogenous goods in the retail market and have transparent and simplified pricing, ComReg found that O2 and Vodafone have the ability to coordinate and thus decided that they have a joint-dominance and the market is not sufficiently competitive. Finding that the market is not functioning properly, it proposed to impose on Vodafone and O2 the obligation to provide network access on non-discriminatory terms, following a reasonable request. But, regarding the ComReg`s findings the EC noted that:

- Although retail market characteristics can be an indicator of the competitiveness of the wholesale mobile market, it can not be conclusive.
- Since Meteor has signed a national roaming agreement with O2, Meteor may put a competitive pressure on O2 and Vodafone and the position of Meteor should also be considered in the analysis of the level of competition in the Irish market.
- Although Hutchison 3G Ireland's market share is low, its role on the level of competition role cannot be discounted entirely.
- Tacit coordination between the top two MNOs could be disrupted even by a relatively small competitor.

Thus, the EC vetoed the ComReg`s findings and asked it to monitor these competitive impacts and re-assess whether MNOs have the ability to impede the entry of MVNOs in the light of the mentioned issues. On the other hand, on appeal of Vodafone, O2, and Meteor to the Electronic Communications Appeals Panel (ECAP), ECAP also overturned the

ComReg`s finding of joint dominance. ECAP`s decision based on the lack of sufficient economic analysis in the ComReg's assessments (NERA, 2007).

Although the EC`s and ECAP`s decisions overturned the ComReg`s findings, these two decisions didn't foreclose the MVNO`s entry. For example, in December 2006, Tesco decided to enter the Irish mobile market as an MVNO through a joint venture with O2, and as of August 2009 there were 13 MVNOs in the Irish mobile market. On the other hand, as seen from the EC`s assessments, the EC`s approach to the competitive effects of even small MNOs is different from the approach of Japanese regulator where it mandated NTT DoCoMo to open its network in a market in which at least one network was open to MVNOs.

## 5. Turkish mobile communications sector

### 5.1. An overview of the market developments

The first mobile telecommunications network, named as Nordic Mobile Telecommunications (NMT), an analogue technology designed and used primarily for the transmission of voice signals, was introduced to Turkish citizens in 1986. 8 Years later, in 1994, Turkey was introduced with the GSM-900 technology, a digital communications technology designed to provide both voice and data services. From 1994 to 1998 two operators, Turkcell and Telsim, provided mobile services under the revenue sharing agreements with the national fixed communications operator Turk Telecom. But in 1998, the Ministry of Transport which did also act as the telecom regulator before the creation of Telecommunications Authority (TA) in 2000, granted Turkcell and Telsim their own 25-years GSM licences for 500 million USD. In 2001, two more GSM operators (Aria and Aycell) were also granted 25-years GSM-1800 licenses for 2.525 billion USD each as a result of the auctions held by the Ministry.

In 2005 Turkey witnessed two important changes in the mobile sector. The first was that the two GSM-1800 operators (Aria and Aycell) merged under a new entity named as Avea and one of the frequency blocks of the merged entity returned to the TA. The other change was the acquisition of Telsim, the second biggest GSM operator in terms of number of mobile subscriptions, by Vodafone for 4.55 billion USD.

In 2008, the new Electronic Communications Law which aligns the Turkish communications legislation with the EU regulations enacted and TA was renamed as Information and Communication Technologies Authority (ICTA). In the same year ICTA auctioned four 3G licences but only three of them could have been sold to the current GSM operators. And now there is a free 3G frequency block held by the regulator. This means that there are now 2 blocks of frequencies, one from GSM-1800 frequency band and the other from 3G bands that can be assigned to the new operators or existing operators as an additional spectrum.

According to ICTA (2009), there were 64.4 million mobile subscribers which correspond to 90% penetration rate as of first quarter of 2009. Today, there are 3 MNOs; Turkcell, Vodafone and Avea all of which use GSM and UMTS technologies. The figures 6(a) and 6(b) show the market shares of mobile operators in terms of subscribers and revenues which change by the time. Looking at the market shares by subscribers and revenues, we can see that the market is dominated by one of the MNOs, but its shares have a tendency to decrease. Another point that can be noted is that the revenues and number of subscribers in the mobile market have a tendency to increase.

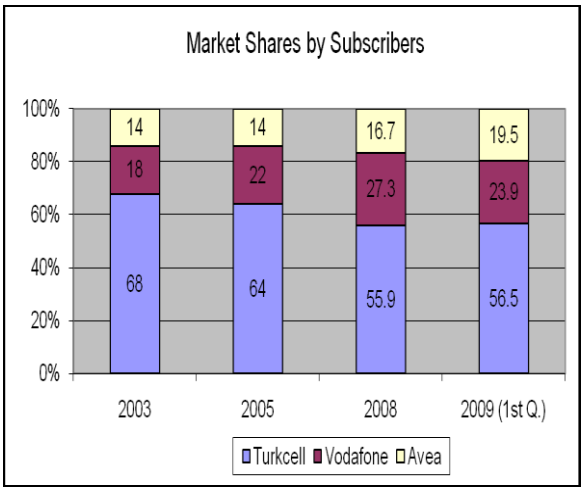



Figure 6(a): Market shares by subscribers[18]

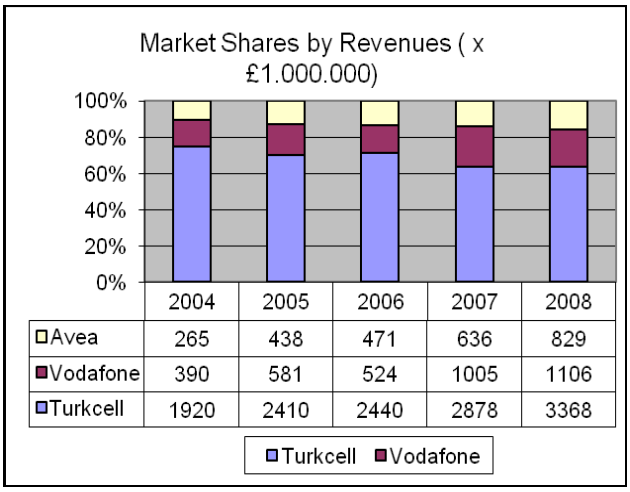



Figure 6(b): Market shares by revenues[19]

The figures 7(a) and 7(b) show the "MNOs` investments to improve the network quality and capacity" and "total traffic carried by each MNO" respectively (ICTA, 2009). It is not surprising to see that the largest operator Turkcell has the largest share in investments also. We can see from Figure 7(b) that the volume of total mobile traffic has been increasing, and the market shares of MNOs changing.

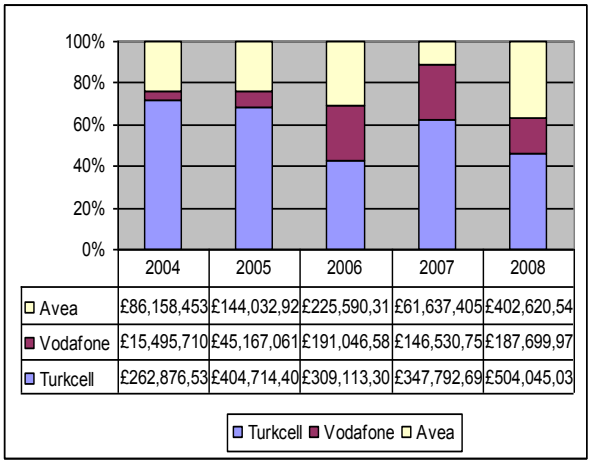



Figure 7(a): Investments by MNOs[20]

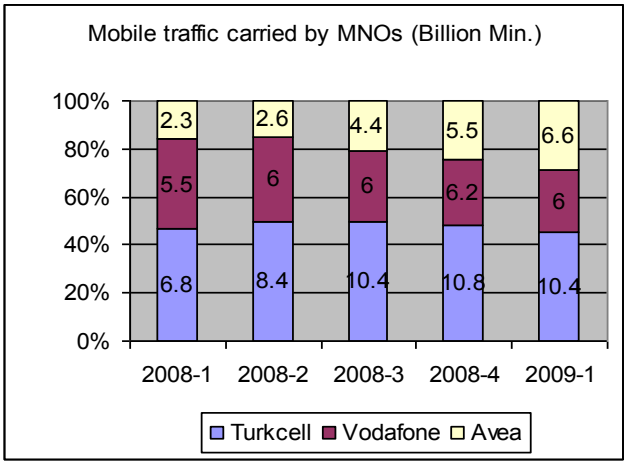



Figure 7(b): Mobile traffic carried by MNOs

In addition to the increase in the number of subscribers, the increase in the volume of mobile traffic can also be considered as an indicator of demand growth for mobile services.

### 5.2. MVNOs in the Turkish mobile communications market

Although 5 MVNOs notified the Turkish regulator and the regulator endorsed their notifications in June and July 2009, they have not yet been operational and they are in the

[18] 2003-2005 figures come from ICTA (2006) and 2008-2009 figures come from ICTA (2009).
[19] The figures are provided in national currencies (TL) but we converted them to Pound Sterling equivalents taking into account the annual average Exchange rates from the Central Bank of the Republic of Turkey.
[20] The same explanation on footnote "19" is also valid for investment figures.

phase of finding a partner for now. According to ICTA (2009) these MVNOs are Net Ankara Inc., Ihlas İletişim Inc., Infoline Inc., TTNET Inc., and KOÇ.NET Inc.[21] Looking at the other businesses that these MVNOs are dealing with we can see that all of them have presence in other sectors like energy refining and distribution, electronic equipment production, retailing, fixed communications services, internet service providing, call centre services, etc.

Another issue that we have to touch here is related to the different financial obligations that MNOs and MVNOs will be subject to despite they will compete in the same markets if the MVNOs could manage to find partners. There are different taxes in Turkey (18% VAT, plus 25% Special Communications Tax (SCT) which was set as a temporary tax in 1999 to raise resource for supporting the areas hit by the Marmara Earthquake in 1999 but has not been removed yet, plus 15% Treasury share) and according to GSM Association (2005) the tax burden on the Turkish mobile customers is the highest in the world. However, what creates a competitive disadvantage for MVNOs with respect to MNOs is due to the legislation which determines the amount that all operators have to pay as Treasury share. The MNOs and MVNOs are not subject to different obligations due to VAT and SCT applications because of the principle of deduction of "pass through revenues". According to this principle the charges payable to MNOs by the MVNOs for the network usage is allowed to be deduced from the gross sales of the MVNOs to obtain the VAT base, and thus double taxation is avoided. But, because of the 1st article of the law numbered 5793, adopted on 24.07.2008, all mobile operators including MVNOs have to pay 15% Treasury share over their gross sales and this law does not allow deducing the "pass through revenues" from Treasury share base. Thus, the charges payable to MNOs by the MVNOs for the network usage is also taxed. In other words, although network access charge is an expense for MVNOs, but revenue for MNOs, the latter are taxed correctly from their gross sales. But the former are also required to pay Treasury share from the same amount as MVNOs are not allowed deducing this amount, which is a "pass through revenue", from Treasury share base (the competition problems due to this legislation is discussed in section 6.3.2).

[21] The trade names of these MVNOs are; Net Ankara Telecommunications Electronics Computer Technologies Inc., Ihlas Communications Inc., Infoline Directory Inquiry and Call Centre Services Inc., TTNET Inc., KOÇ.NET Communication Technologies and Communication Services Inc.

## 6. Analysis and discussion

### 6.1. Implications from economic papers and case studies

Although MVNOs are expected to bring more price and service competition to the mobile markets and most of the countries allowed them to operate, the previous studies and some of the regulatory approaches which either mandate MNOs to open their networks for MVNOs or leave it to the market show that there is no general consensus on whether MNO-MVNO relationship should be regulated or not. Meanwhile, the economic papers and empirical research show that there is no need to intervene in this relationship if MVNOs are expected to bring more economic benefits than costs for MNOs and the necessity of ex-ante regulatory intervention to support MVNOs is highly questionable.

The monopolistic owner of a bottleneck production factor which also competes in the downstream market and provides the input to the downstream competitors may have an incentive to restrict access to the input and thus limit competition in the downstream market, but the incentives of the oligopolistic incumbents are different, and in mobile markets the MNOs are expected to grant access to their networks most of the time depending on the input differentiation, product differentiation, market size, absence of collusion to impede entry, and absence of capacity constraints. We have discussed above that mandating MNOs to provide open access has a potential to discourage investments, but if the services provided by MVNOs are sufficiently differentiated, then there is no reason to suspect from a discourage in incentives for investments as most of the MNOs are expected to grant access to their networks voluntarily. Moreover, it has been discussed that agreements that contain non-compete obligations for the entrant is likely to lead to an entrant being supplied. As the entrant promises not to compete for the supplying incumbent's customers but commits to trying to find different customers and differentiated services, non-compete agreements can be considered as the agreements that forces MVNOs to provide differentiated services. Thus, these obligations make it more attractive the MVNOs to be supplied by the MNOs.

If the factors that create economic incentives for MNOs to supply the MVNOs exist then MVNOs are expected to be supplied by the MNOs voluntarily. But, despite the existence of such factors if there are no contractual relationships between MNOs and MVNOs in a market where there are no legal entry barriers and capacity constraints then regulators can suspect from collusion among the MNOs. Put differently, before imposing obligations on MNOs to open their networks, the regulators should assess whether the market is sufficiently competitive. If they found that the market forces are working properly, even if there are no MVNOs, then there is no scope for regulatory intervention. But, if they establish that competition on price or quantity is not sufficient, then the regulators should find the remedies

to increase competition in the retail market. Although there might be other remedies to decrease market power due to single or joint dominance, like introducing mobile number portability and preventing customer loyalty programs beyond a certain period[22], another remedy might be increasing competition in the wholesale market. If competition in the wholesale market is sufficient then new entrants, like MVNOs, are expected to enter the market and increase competition in the retail market. Considering that single dominance is not sufficient to deter entry of MVNOs as the other market players are likely to grant access if economically beneficial for them, the absence of MVNOs in a market might be due to the existence of joint dominance. By examining the market characteristics provided in Appendix-I and applied for the Turkish mobile sector in the next section we can get an insight about the existence of joint dominance in a market.

Finally, the absence of MVNOs in a market can be the consequence of effective competition in the retail market. If MVNOs observe fierce competition in the retail market they may not expect any benefit from entry or may fear from loss and thus they may not have an incentive to enter at all. Fortunately, in such a case there is no need to worry about the absence of MVNOs as the retail market has already produced the desired competitive outcome.

### 6.2. Assessing the competitive effects of MVNOs based on statistical data

As discussed in section 2.3, according to economic theory of competition prices are expected to decrease in response to an increase in the number of operators in a market. In this context, the aim of this section is; (i) to investigate whether an increase in the number of MVNOs have an observable impact on mobile prices; and (ii) to compare the prices in countries where MVNOs are operational and where they are not.

To examine the relationship between prices and the number of MVNOs we used OECD (2009) mobile price indicators from 29 countries and took into account the number of MVNOs in those countries (see Appendix-II for the information used). To observe MVNOs` impact on mobile prices, we graphed a scatter plot and run an OLS regression. As seen from the scatter plot (Figure 8) an increase in the number of MVNOs has an impact on prices to decrease. However, we needed to test its significance by regressing the “mobile price” over “number of MVNOs”. We can see from the regression output below the scatter plot that the coefficient of “numberofmvno” which is used as a predictor is not statistically significant. This result suggests that the number of MVNOs do not have statistically significant impact on mobile prices.

[22] For example, 1 year loyalty programs may be reasonable but a 3 or 4 year tying programs should be assessed carefully by the regulator as the effect of such a program may be abusive.

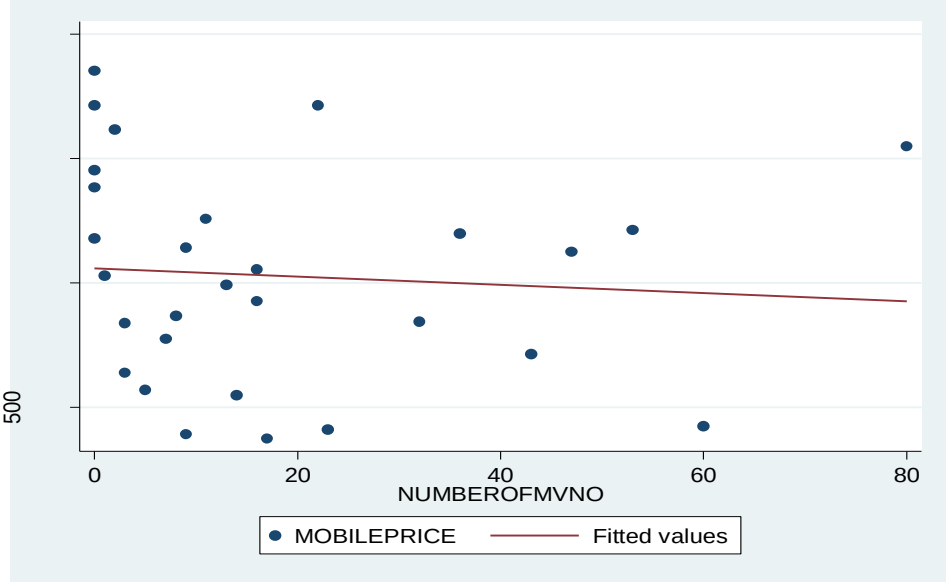



Figure 8: Relationship between the number of MVNOs and prices

```
. regress  mobileprice numberofmvno
```

| Source | SS | df | MS |
|---|---|---|---|
| Model | 33008.1078 | 1 | 33008.1078 |
| Residual | 5124043.06 | 27 | 189779.373 |
| Total | 5157051.17 | 28 | 184180.399 |

| | |
|---|---|
| Number of obs | 29 |
| F( 1, 27) | 0.17 |
| Prob > F | 0.6799 |
| R-squared | 0.0064 |
| Adj R-squared | -0.0304 |
| Root MSE | 435.64 |

| mobileprice | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| numberofmvno | -1.650027 | 3.956446 | -0.42 | 0.680 | -9.767984 | 6.46793 |
| _cons | 1057.604 | 108.5011 | 9.75 | 0.000 | 834.9781 | 1280.23 |

It can be foreseeable that mobile prices can be explained by other explanatory variables such as availability of alternative access paths, prices of the alternative communication means, cost differences of mobile services, and the existence or absence of MVNOs in markets. For that reason, we added two of these variables as potential predictors of mobile prices: "total access paths per 100 inhabitants"[23] (considering that if there are alternatives to mobile networks, the prices should be lower); and "dummy variable" (to see whether the countries with MVNOs have lower mobile prices) which show the existence or absence of MVNOs in the sample. If MVNOs are present the dummy takes "1" and if not "0". As there are no MVNOs in Czech Republic, Greece, Hungary, Mexico, and Turkey[24] (OECD, 2009; www.telecompaper.com), the dummy variable for these countries takes "0" and for others it takes "1". Regressing mobile prices over number of MVNOs, total access paths and dummies we can obtain the following output.

[23] Total access paths shows the number of total access paths including analogue lines, ISDN lines, DSL, cable modem, fibre optics and wireless access paths per 100 inhabitants

[24] Although there are 5 notified MVNOs in Turkey, as they have not started commercial activities yet, the number of MVNOs is given as "0".

```
. regress  mobileprice numberofmvno totalaccesspaths d1
```

| Source | SS | df | MS | Number of obs = | 29 |
|---|---|---|---|---|---|
| Model | 2081386.11 | 3 | 693795.371 | F( 3, 25) = | 5.64 |
| Residual | 3075665.06 | 25 | 123026.602 | Prob > F = | 0.0043 |
| | | | | R-squared = | 0.4036 |
| | | | | Adj R-squared = | 0.3320 |
| Total | 5157051.17 | 28 | 184180.399 | Root MSE = | 350.75 |

| mobileprice | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| numberofmvno | 3.227554 | 3.489784 | 0.92 | 0.364 | -3.95979 | 10.4149 |
| totalacces~s | -5.397213 | 2.628497 | -2.05 | 0.051 | -10.8107 | .0162779 |
| d1 | -516.2825 | 202.4377 | -2.55 | 0.017 | -933.2108 | -99.35415 |
| _cons | 2302.834 | 413.6081 | 5.57 | 0.000 | 1450.992 | 3154.676 |

According to this STATA output, there is a negative correlation between the mobile price and total access paths which is statistically significant at 95% confidence interval which implies that the higher the number of access paths per 100 inhabitants, the lower the prices. But, the coefficient of the "number of MVNOs" which is used as another predictor is not significant at even 90% confidence interval. Comparing the mobile prices with and without MVNOs as explained in footnote 25 we can state that MVNOs` presence has an impact on mobile prices to decrease from 2304.83 to 1788.55 all other things being equal[25]. On the other hand we can use the scatter plot to observe mobile prices depending on the dummies only. The points on the left hand side of the graph show the mobile prices where there are no MVNOs, and the points on the right show the mobile price where there are MVNOs. As seen from the graph the average price is lower in the countries where MVNOs are operational.

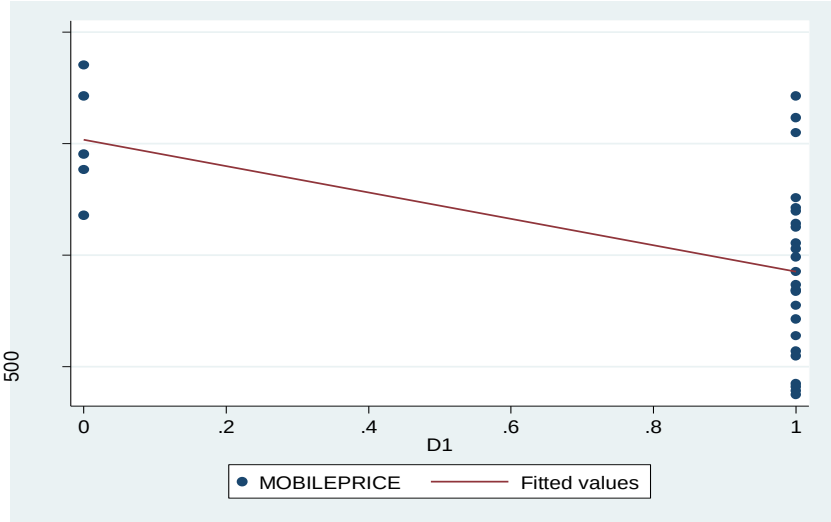



Figure 9: Mobile prices in countries with and without MVNOs

[25] Using the regression output we can write the model for "mobile price" as; Mobileprice = 2304.83 + 3.22.numberofmvno – 5.39.totalaccesspaths - 516.28.(d1).

- If MVNOs are operational, the equation becomes; Mobileprice = 2304.83 + 3.22.numberofmvno – 5.39.totalaccesspaths – 516.28.(1), which simplifies to: Mobileprice = 1788.55 + 3.22.numberofmvno – 5.39.totalaccesspaths.
- If there are no MVNOs, the model takes the form; Mobileprice = 2304.83 + 3.222.numberofmvno – 5.39.totalaccesspaths - 429.58.(0), which simplifies to: Mobileprice = 2304.83 + 3.222.numberofmvno – 5.39.totalaccesspaths.

Thus, we can conclude that while the number of MVNOs has not yet sufficient impact on mobile prices that can be observable statistically, the presence of MVNOs has.

Although it is expected theoretically that an increase in the number of operators in a market should have an impact on prices to decrease; we found empirically that MVNOs do not have significant impact on prices. This outcome indicates that the MVNOs` impact on prices is masked by country specific price differences. For example, mobile prices in Turkey seem high and the main reason behind this is the high taxes which amount to 58% (including Treasury share) that triples EU average. As an another example, according to OECD (2007), one of the main reason behind the high prices in Japan is the lack of the prepaid calling plans that allow use of mobile phones without a set monthly subscription fee. As the mobile prices have a tendency to decline in almost all countries every year and there are big price differences in different countries (OECD, 2009; EC, 2008), to reveal the actual effects of MVNOs on mobile time series data for each country can be collected and thus whether the entry of MVNOs created a price difference between pre and post MVNO mobile prices in each country can be analysed as a further study.

### 6.3. Applying theory and practice for Turkish mobile market

The Turkish mobile market is an oligopolistic market with three active MNOs and three different mobile infrastructures. Thus, any assessment regarding MNO-MVNO relationship should be based on this market structure. Moreover, since one of the objectives of the regulation is removing regulatory uncertainties, the Turkish regulator should determine its stance whether the 2 blocks of available frequencies would be assigned to new facility based entrants or current MNOs as an additional resource before dealing with the MNO-MVNO relationship. If regulator chooses introducing new MNOs, the number of operators in this oligopoly would increase further and there is no need to deal with MNO-MVNO relationship as the newcomers are likely to spur competition at the wholesale markets and MNO-MVNO relationships are likely to be established voluntarily. However, if the regulator's ultimate decision is not introducing new MNOs and utilizing unused frequencies by, for example, assigning to the current MNOs, then the regulator can focus on MNO-MVNO relationship. Fixing the regulatory decision whether the new MNOs will be assigned new spectrum blocks or not would mean that potential new MNOs or MVNOs could see the future and depending on this regulatory decision they can also make their decisions about whether to enter as MNOs and build their networks, or as MVNOs and buy the capacity from existing MNOs.

Since there are 5 notified MVNOs in Turkey but they have not been commercially operational yet, the regulator needs to assess the reason behind the MVNOs` inability to start activities. However, given the entry of MVNOs into the Turkish mobile market is a recent issue (June

and July 2009) it may be too early to attribute the absence of commercial operations to the unsuccessful negotiations between MNOs and MVNOs. If an MNO-MVNO relationship is established voluntarily because of the economic incentives of the parties then there is no need for regulatory intervention. But if such a relationship can not be established then it is needed to investigate the rationale behind this outcome. If, the absence of MNO-MVNO contractual relationships is due to the competitive behaviour of MNOs, such as low prices in the retail market or absence of unilateral economic incentives of MNOs, then again there is no need to intervene the market. But if it is because of the collusive behaviour of the MNOs which can be considered as one of the market failures, then regulatory intervention can be justified. Thus, before imposing an obligation on MNOs to provide wholesale access for MVNOs the regulator needs to investigative whether Turkish mobile market creates sufficient incentives to establish an MNO-MVNO relationship, whether there are capacity constraints or whether there is a market failure that prevents contractual relationship between the parities.

### 6.3.1. Assessing the economic incentives of MNOs to provide network access

We have discussed that an MNO-MVNO relationship is expected to be established voluntarily if some market conditions create economic incentive for MNOs to open their networks for the MVNOs. In the following paragraphs it is discussed whether market conditions create such incentives for Turkish MNOs.

- **Absence of regulatory impediments for the entry of MVNOs:**

To assess the MNO-MVNO relationship, first of all it should be assumed that there are no legal entry barriers for MVNOs. Otherwise it would have been meaningless to examine the MNO-MVNO relationship. Following the adoption of the Electronic communications law in November 2008 which aligns the Turkish communications legislation with the EU regulations the MVNOs were allowed to enter the Turkish mobile market in June 2009 which means that there are no legal barriers for MVNOs to enter the market.

- **Absence of capacity constraints:**

One of the factors that should be considered when assessing the economic incentives of MNOs to provide access is reviewing the capacity constraints of MNOs. Should they have capacity constraints, imposing obligations on MNOs to provide network access will be highly questionable. There are some literatures, such as Spence (1977), which argue that the incumbents can use their excess capacity as a tool in deterring entry. But, in the absence of collusion among MNOs, they will have an incentive to utilize the spare capacity as seen from the Dutch experience and supported theoretically by Mason and Nowell (1992) which argue that holding excess capacity to deter entry is not rational if capacity costs are high.

Considering the vast amount of money that most of the MNOs paid to own frequencies and build networks, it can be argued that holding these resources unused shouldn't be rational for MNOs.

We do not have sufficient information whether the Turkish MNOs have excess capacities. However, the regulator should clarify whether they have spare capacities taking into account the established networks which include transmission capacities, data storage capacities like HLRs, VLRs, etc.; assigned frequencies; and subscribers when assessing the necessity of regulatory intervention to the MNO-MVNO relationship. Despite all of the Turkish MNOs have national coverage there are big differences in their mobile subscribers and in their investments (see section 5.1) which suggests that they shouldn't have the same spare capacities. On the other hand, if the MNOs were assigned equal frequencies, the small ones should have more unused frequencies and it is expected that these MNOs which have high spare capacities should have incentive to accept MVNOs. Thus, if the regulator establishes that the MNOs have excess capacities, it can be concluded that they are expected to have incentives to provide network access to the MVNOs which can be taken as one of the factors that casts doubt on the necessity of regulatory intervention.

On the other hand, despite their inability to use their assigned frequencies or in general terms to use their capacities if they are denying the MVNO access the regulator can suspect from coordination among MNOs on capacity utilization. Moreover, as these unused frequencies can be considered as the waste of national resources which can justify the regulatory intervention, to make use of these frequencies effectively the regulator can force the MNOs to open their networks for the MVNOs which target the market niches.

- **Input differentiation:**

If the inputs that MNOs provide MVNOs are homogenous, the MNOs will have an incentive to provide network access. There might be slight differences between the wholesale inputs of Turkish MNOs due to, for example, quality of service, coverage etc. But, since all of the three MNOs are national and provide the same type of services, like voice, SMS, MMS, mobile internet etc, the inputs can be considered as homogenous. As the inputs are considered as homogenous, the MVNOs are more likely to be supplied by the MNOs because of proportional cannibalization (see footnote 8) effect of the MVNOs.

- **Product (service) differentiation:**

Should the services provided in the downstream market are differentiated which includes targeting niche markets by MVNOs, it is expected that the MNOs will have an incentive to open their networks for MVNOs. Given that the Turkish MVNOs have presence in other

sectors, it is expected that these MVNOs are likely to reach their customers more easily than the national MNOs if they could manage to sign wholesale agreements with the MNOs. For that reason, national MNOs are expected to have an incentive to sign wholesale agreements with the MVNOs that are strong with respect to customer bases. Moreover if these MVNOs able to develop new services that are differentiated from the MNOs` services then again it is expected that the MNOs` incentives to host MVNOs will increase. If the MVNOs do not provide differentiated services, it means they will provide services similar to MNOs` services and thus target the MNOs` customers; which creates an incentive for MNOs to refute the access. Although we do not now whether the MVNOs have strategies to improve innovative services, we know that all of them have presence in other businesses and creates a product differentiation at least on customer bases.

- **Market size:**

It seems it is unanimously agreed that if the services provided by MVNOs are differentiated they are expected to find partners from MNOs voluntarily. But, even if they provide homogenous products they are also expected to find partners under Cournot competition if the market is sufficiently large as discussed by Dewenter and Haucap (2006). We can extend their model with two incumbents to three MNOs to assess the market conditions to come to voluntary agreements between these MNOs and a number of MVNOs in Turkey. If the inverse demand function is linear and given by $P = A - bQ$; *"n", "m", s"* are the number of MVNOs roaming on these MNOs respectively; and *"f"* is the fixed cost of granting MVNO access; the relationship between the number of MVNOs and market size can be given by;

$\frac{n+2}{(3n+4)^3} = \frac{m+2}{(3m+4)^3} = \frac{s+2}{(3s+4)^3} = \frac{f.b}{A^2}$, which means that any positive values of *"n", "m",* and *"s"* are the profit maximizing number of MVNOs for each MNO depending on *"f", "b",* and *"A"* (see Appendix III for details).

Although we do not have sufficient information about fixed costs, price elasticity and market size which are measured by "f", "b", and "A" respectively, the Turkish regulator can make an assessment about the number of MVNOs that are expected to be accepted by MNOs relying on the values of "f", "b", and "A". As it is seen, the larger the market size compared to fix costs, the higher the number of MVNOs which are expected to be provided network access by MNOs voluntarily.

- **Absence of collusion to impede entry:**

It is not possible for a dominant MNO to prevent the MVNO`s entry unilaterally if the others have an incentive to provide wholesale access. Thus, to reveal the reasons behind the

absence of commercial activities of MVNOs, we need to examine whether MNOs are coordinating to prevent entry or not. Relying on the Appendix-I which summarizes the factors that affect the incentives of MNOs to coordinate, we can make the following assessments for the Turkish mobile market:

**The number of competitors and concentration level:** There are three MNOs with market shares of 56.5%, 23.9% and 19.5%. And HHI index is calculated as 4143. This number of MNOs and the level of HHI could be seen as one of the indicators that facilitate coordination. However, high HHI index can not tell the whole story about coordination and other factors should be examined to see whether coordination is likely in the Turkish mobile market.

**Barriers to entry:** Although there are no barriers to entry for MVNOs, to examine the possibility of coordination among MNOs, here we need to assess whether there are entry barriers for new MNOs. As we discussed, there are two available frequency blocks that can be assigned to new MNOs and if the regulator decides to sell these frequencies, there will be no barrier to entry for MNOs. But if the regulator's ultimate decision is not to allow the entry of new MNOs then, collusion or collective dominance assessments should be made based on the existing market situation with three MNOs. Based on the assumption that the regulator's decision is maintaining the status quo in the foreseeable future, we can state that barriers to entry exists which is one of the factors that facilitate coordination.

**Market shares of the MNOs:** Although stable market shares is considered as one of the indicators of the collusive outcome, the fluctuating market shares sign a competitive market. As seen from section 5.1, market shares of the Turkish MNOs have been changing and the largest operator`s market share has been eroding which can be taken as one of the strong indicators that the MNOs have not been coordinating their activities.

**Price movements and price levels:** Another point that should be investigated is whether the MNOs coordinating on prices. Parallel price movements can be an indicator of collusive behaviour of incumbents. But when examining the price movements, the regulator needs to purge the common effects on price movements. For example price increases due to the new taxes such as Special Communication tax examined in section 5.2 shouldn't be perceived as a price increase because of collective dominance. On the other hand, although we do not have sufficient data, the regulator needs to examine whether the prices are excessive compared to competitive prices or marginal costs. If it finds excessive prices it may imply that the MNOs have an incentive to refuse the access to sustain this outcome.

**Capacity constraints and investments:** Similarity of capacity constrains can also create an incentive to collude. The arguments made above to assess the economic incentives of

MNOs to provide network access is also valid for the assessment about whether MNOs have an incentive to collude. Based on this assessment we expect that capacity constraints of Turkish MNOs do not serve as a factor that facilitates collusion.

**Investments:** The investments of the MNOs have also some fluctuations which support the view that operators have not been colluding.

**Demand Growth:** Growing demand is considered as one of the factors that facilitates collusion. As seen from Figures 6(a), 6(b) and 7(b); the number of subscribers, the mobile revenues and volume of traffic has been increasing for a couple of years which implies a demand growth for mobile services. But, taking into account the fluctuating market shares of MNOs by subscribers, by revenue and by volume of traffic we can conclude that there is no collusive behaviour related to demand growth.

**Buyer power:** With more than 64 million buyers of legal and natural persons, we can not see a single buyer or group of buyers that exert competitive pressure on MNOs. But, churn rates can be considered as an indicator of buyer power. According to Ruan *et al.* (2008, p.744) with an average churn of between 3%-6% Turkish MNOs have very high churn rates when compared to the international average of 2.2% as of 2007. This high churn rates show that the buyers have the ability to make use of their bargaining power to stimulate competition.

Although there are still some points such as whether new MNOs will be allowed to enter, and whether the existing MNOs colluding on prices etc, which should be analysed by the regulator for a healthy assessment of whether the MNOs coordinating, based on the above assessments we expect that coordination is difficult to be achieved in Turkish mobile market which suggest that the current absence of contractual relationships between MNOs and MVNOs shouldn't be the outcome of the coordination in the market.

### 6.3.2. Assessing the impact of Treasury share obligations on competition

We had stated in section 5.2 that the MVNOs are likely to suffer from unequal financial burden due to the Treasury share obligations. To make the issue clearer, assume that the position of MNOs and MVNOs in the market is as shown in figure below where MNOs are competing in the upstream and downstream markets and MVNOs are competing only in the downstream market. Assuming that MVNOs do not have any other costs rather than input price, if MNOs charge the access price "a" to the MVNOs, and MVNOs charge the price "b" to end users, then "b" should be greater than or equal to "a" ($b \geq a$) in order for MVNOs do not incur a loss. But, since MVNOs have to pay 15% Treasury share over their gross sales (assuming that "b" is the gross sales of the MVNOs), "b" should be at least "$1.176a$".

Because, MVNOs should charge end users by calculating the amount they will pay as Treasury share and add it onto their input price which produces at least input price after deducing the Treasury share from their gross sales. For example, if “a” is £10p, then MVNOs should charge end users at least £11.76p, 15% of which is £1.76p which should be paid as Treasury share and after deducing this amount MVNOs own £10p and pay it to the MNOs as wholesale rent.

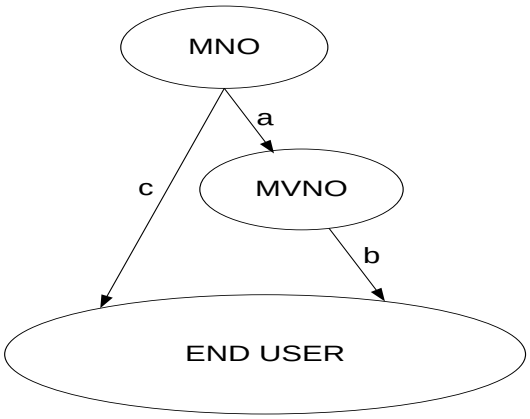



Figure 10: MNO-MVNO-customer relationship

On the other hand, for MVNOs to be able to compete with MNOs, “b” should be less than or equal to “c” which is the price that MNOs charge to end users. Thus, even if the parties agree on a voluntary relationship, for MVNOs to compete with MNOs in Turkey, the following condition should hold:

$$a \leq \frac{b}{1.1764} \leq \frac{c}{1.1764}$$

To sum up, if the mentioned article of the law would not be corrected, when started commercial activities MVNOs will have a disadvantage and there will be double taxation over the network access charges. On the other hand if regulatory intervention is justified, in addition to access pricing methods, like ECPR, this point should also be addressed by the regulator.

## 7. Concluding remarks

In this paper it is aimed to investigate whether the regulators should intervene in the relationship between access providers and access seekers in oligopolistic mobile telecommunications markets and in this context it is aimed to provide an insight for the regulatory approach for the MNO-MVNO relationship in the Turkish mobile market.

The literature, and regulatory approaches which either mandate MNOs to open their networks for MVNOs or leave it to the market, show that there is no general consensus on whether MNO-MVNO relationship should be regulated or not. But, since the voluntary agreements between MNOs and MVNOs would naturally take into account both MNOs` and MVNOs` benefits; and since one of the most fundamental objectives of the regulation and competition policies is to tackle with the market failure such as denial of MVNO access to the MNOs` networks as a result of collusion among MNOs; it proposed that the voluntarily established relationships should be preferred to regulated relationships. But even if regulatory intervention is seen as a requirement to eliminate the market failure and facilitate MVNOs` entry, these regulations should be economically justified. If the economic analysis reveals sufficiently competitive market conditions to mitigate the concerns of market failure or if it reveals that the market conditions create sufficient incentives for the access providers to provide network access to access seekers then there might be no necessity to intervene in the market forces.

Although allowing MVNOs to operate, which results in an increase in the number of operators, is seen as one of the tools to increase competition in the mobile telecommunications sector, we have found that the impact of MVNOs on mobile prices is not significant for today and can not be detected statistically. However, as the mobile prices have a tendency to decline in almost all countries and there are big price differences in different countries it seems that the actual impact of MVNOs on prices is masked by the country specific market conditions. By collecting time series data for countries and analysing whether the entry of MVNOs created a price difference between pre and post MVNO mobile prices in each country, the actual impact of MVNOs on prices can be revealed as a further study.

As they have been allowed to enter the market quite recently, the Turkish MVNOs are not operational for now and they are in the phase of finding partners from incumbents. However, we expect that in addition to existing ones new MVNOs with strong brand names may continue to enter the market and voluntary relationships can be established without regulatory intervention in the near future. But in any case, current absence of contractual relationships between MNOs and MVNOs shouldn’t imply a market failure without

investigating the rationale behind this. Although we lack some of the information which should be taken into account by the regulator while assessing the issue as discussed in Chapter 6; we expect that it is difficult for Turkish MNOs to deny the MVNO access to their networks as a result of collusive behaviour, and the characteristics of Turkish mobile telecommunications market would create sufficient incentives for MNOs to provide network access for MVNOs.

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**APPENDIX – I**

**Factors that affect the incentives of MNOs to coordinate**

Although single dominance is considered as a threat for competition, one of the other threats to competition is the coordination among the firms in a market. Coordination can be explicit or tacit but as the explicit coordination is generally prohibited by the competition laws in countries, this brief only reviews the market characteristics that are likely to affect the incentives of oligopolistic firms to collude or coordinate their activities tacitly. This brief has been prepared depending heavily on Ivaldi *et al.* (2003) and Motta (2004, p.142), but the readers are recommended to refer to these references for detailed analysis of factors that facilitate coordination.

- **The number of competitors and concentration level:** Coordination is more difficult the larger the number of parties involved. If the number of firms increases, each firm gets a lower share of the collusive profit which increases the incentives to deviate and get the higher share of the market.
- **Entry barrier:** In the absence of entry barriers any attempt of the established firms to maintain high prices would trigger entry which can be considered as a threat for collusive outcome.
- **Market shares:** Symmetric market shares facilitate coordination and the higher the asymmetry in market shares the lower the possibility for coordination. Historic market shares can also provide useful information about the competitive dynamics of a market: for example, volatile shares might suggest that there has been effective competition
- **Firm asymmetry:** Symmetry among firms is regarded as a factor that facilitates collusion. Symmetry includes different dimensions such as symmetry in market shares, product portfolio, cost functions, capacities. Symmetry in incentives between the collusive groups also matters: although symmetry in market powers facilitates the collusive outcome, a maverick firm may disrupt coordination because of asymmetric incentive.
- **Capacity constraints:** Asymmetries in capacity constraints hinder collusive outcome. Compared with a situation where all firms face the same capacity constraints, increasing the capacity of one firm at the expense of the others increases the first firm's incentive deviate from collusion.
- **Structural links between competitors:** If a firm has a participation in a competitor in a way like by holding some shares or by controlling the latter, the scope for the collusion increases.

- **Exchange of information:** Since information on prices and quantities of firms give an opportunity for the collusive group to identify the deviator and punish it, exchange of information on prices or quantities of each individual firms facilitate collusion.
- **Transparency:** Anything that increases transparency (for example applying list prices in the market) increases the coordination incentive and anything that decreases the transparency decreases this incentive.
- **Demand growth:** For a given number of firms in a market, collusion is easier to sustain in growing markets, where today's profits are expected to be small compared with tomorrow's profits.
- **Regularity and frequency of orders:** Regular orders facilitate collusion and unusually large orders give an incentive to deviate from the collusion.
- **Absence of buyer power:** A strong buyer can make use of its bargaining power to stimulate competition among the sellers.
- **Product differentiation:** The more homogenous the products, the easier to coordinate the collusive outcome.

**APPENDIX – II**

**Data used in Section 6.2 to assess the impacts of MVNOs on prices**

The table below shows the countries included in the analysis; mobile prices; number of MVNOs; total access paths per 100 inhabitants and dummy variables for each country. "Mobile Price" column shows the mobile price per year in PPP (including VAT) and found by the sum of low, medium and high usage OECD mobile baskets.[26] "Number of MVNOs" shows the number of MVNOs per country as of August 2009 and obtained from www.telecompaper.com. "Total Access Path" shows the number of total access paths including analogue lines, ISDN lines, DSL, cable modem, fibre optics and wireless access paths per 100 inhabitants (OECD, 2009). And the dummy variable "D1" takes value "1" if MVNOs are present in a market and "0" if there are no MVNOs.

| | Countries | Mobile Price | Number of MVNOs | Total Access Paths | D1[27] |
|---|---|---|---|---|---|
| 1 | United States | 1549 | 80 | 160 | 1 |
| 2 | Italy | 1054 | 16 | 204 | 1 |
| 3 | Japan | 868 | 8 | 146 | 1 |
| 4 | Spain | 1714 | 22 | 170 | 1 |
| 5 | Slovak Rep. | 1618 | 2 | 141 | 1 |
| 6 | Canada | 1258 | 11 | 145 | 1 |
| 7 | Portugal | 1142 | 9 | 170 | 1 |
| 8 | New Zealand | 838 | 3 | 165 | 1 |
| 9 | Belgium[28] | 1212 | 53 | 159 | 1 |
| 10 | Australia | 845 | 32 | 172 | 1 |
| 11 | Poland | 926 | 16 | 141 | 1 |
| 12 | Germany | 1125 | 47 | 187 | 1 |
| 13 | France | 1198 | 36 | 153 | 1 |
| 14 | UK | 713 | 43 | 195 | 1 |
| 15 | Ireland | 993 | 13 | 175 | 1 |
| 16 | Austria | 569 | 5 | 170 | 1 |
| 17 | Switzerland | 775 | 7 | 191 | 1 |
| 18 | Korea | 1030 | 1 | 165 | 1 |
| 19 | Norway | 549 | 14 | 173 | 1 |
| 20 | Luxembourg | 638 | 3 | 222 | 1 |
| 21 | Netherlands | 423 | 60 | 174 | 1 |
| 22 | Sweden | 410 | 23 | 195 | 1 |
| 23 | Finland | 390 | 9 | 179 | 1 |
| 24 | Denmark | 374 | 17 | 194 | 1 |
| 25 | Czech Rep. | 1853 | 0 | 167 | 0 |
| 26 | Greece | 1383 | 0 | 202 | 0 |
| 27 | Hungary | 1180 | 0 | 156 | 0 |
| 28 | Mexico | 1454 | 0 | 88 | 0 |
| 29 | Turkey[29] | 1715 | 0 | 115 | 0 |

[26] The low usage basket includes 360 voice calls, 396 SMS and 8 MMS messages per year. The medium usage basket includes 780 voice calls, 600 SMS and 8 MMS messages. And the high usage basket includes 1680 voice calls, 660 SMS and 12 MMS messages per year.

[27] The data whether there are MVNOs is obtained by cross-checking OECD (2009) and www.telecompaper.com.

[28] Mobile price for Belgium is obtained from combining OECD Communications Outlook 2007 and 2009 data.

[29] As 5 Turkish MVNOs have not started commercial activities yet, the number of MVNOs is given as "0".

**APPENDIX – III**

**Details of discussion about "Market size" in Section 6.3.1**

If the inverse demand function is given by $P = A - bQ$, where "P" is the market price and "Q" is the total output; and "n", "m", s" are the number of MVNOs roaming on three MNOs respectively, then total output can be given as,

$Q = q1 + q2 + q3 + \sum_{i=1}^{n} qi + \sum_{j=1}^{m} qj + \sum_{k=1}^{s} qk$, where "q1", "q2" and "q3" are the outputs of individual MNOs and "qi", "qj" and "ql" are the outputs of the MVNOs.

Applying Cournot competition for this function, we can find the equilibrium quantity and equilibrium price as follows. The first MNO`s profit function is given by;

$\prod_1 = P.q1$.

Since $P = A - b.Q$, $\prod_1 = (A - bQ).q1$

$$\prod_1 = \left[ A - b.(q1 + q2 + q3 + \sum_{i=1}^{n} qi + \sum_{j=1}^{m} qj + \sum_{k=1}^{s} qk) \right].q1$$

The FOC for this profit function with respect to "q1" is given by;

$$\frac{\partial \prod_1}{\partial q1} = A - 2.b.q1 - bq2 - bq3 - b.(\sum_{i=1}^{n} qi - \sum_{j=1}^{m} qj - \sum_{k=1}^{s} qk)$$

Then, the equilibrium quantity, "q*", can be found by substituting "q1", "q2", "q3", "qi", "qj", "qk" by "q*", and solving for "q*". Thus we can obtain "q*"as;

$$q^* = \frac{A}{b(4 + n + m + s)}.$$

And the equilibrium price, "p*", can be found by substituting the equilibrium quantity into inverse demand function. Since $P = A - bQ$,

$p^* = A - b.\left[ \frac{3A}{b.(n + m + s + 4)} + \frac{A.(n + m + s)}{b.(n + m + s + 4)} \right]$. Making the necessary simplifications, we can obtain the equilibrium price as;

$$p^* = \frac{A}{(4 + n + m + s)}.$$

Assuming, analogously to Dewenter and Haucap (2006), "n" number of MVNOs are roaming on the first MNO, the first MNO`s profit can be given by; its own profit from retail market plus profit from MVNOs as wholesale rents minus its own fixed costs minus fixed costs due to granting access to MVNOs.

And, assuming there are many MVNOs which needs wholesale access from 3 MNOs to provide mobile services, MNOs can be considered as sellers and MVNOs as buyers. If MNOs could solve the commitment problem through vertical restraints such as exclusive dealing or exclusive supply agreements, competitive bidding to obtain the network access will lead the MVNOs to offer their expected profit from downstream market to the MNOs (Motta, 2004, p.339) which means that MNOs extract full surplus from MVNOs. Surely, if MVNOs pay whole surplus to the MNOs then there is no reason for them to enter into the market, but if many MVNOs competing to obtain network access then it can be assumed that the margin between their revenue from retail market and the amount payable to MNOs shrinks to zero. To sum, we can assume that the MNOs extract full surplus from MVNOs.

Thus, if there are "n" number of MVNOs roaming on the first MNO, the first MNO`s profit can be given by; its own profit from retail market plus profit from MVNOs as wholesale rents minus its own fixed costs minus fixed costs due to granting access to MVNOs.

So, the first MNOs profit in equilibrium market condition is given by; $\prod_1 = p^*.q^* + n.MVNOs`profit - (F + n.f)$, which is equal to

$$\prod_1 = \frac{A}{n+m+s+4}.\frac{A}{b.(n+m+s+4)} + n.(\frac{A}{n+m+s+4}.\frac{A}{b.(n+m+s+4)}) - (F+n.f).$$

Making the necessary simplifications; we can obtain the first MNO`s profit function as,

$$\prod_1 = \frac{A^2(n+1)}{b(n+m+s+4)^2} - (F+n.f).$$

Since we have a profit function which is dependent on the number of MVNOs and other variables, to find the profit maximizing number of MVNOs we need to find the FOC of the $\prod_1$, $(\frac{\partial \prod_1}{\partial n} = 0)$.

$$\frac{\partial \prod_1}{\partial n} = \left[\frac{A^2}{b}.\frac{n+1}{(n+m+s+4)^2} - (F+n.f)\right]` = \frac{A^2}{b}.\left[\frac{1.(n+m+s+4)^2 - 2.(n+m+s+4).(n+1)}{(n+m+s+4)^4}\right] - f.$$

After making the necessary simplifications we obtain,

$$\frac{\partial \prod_1}{\partial n} = \frac{A^2}{b}\left[\frac{m+s-n+2}{(n+m+s+4)^3}\right] - f\ .$$

As the number of MVNOs are determined endogenously by three MNOs, they can be assumed equal (m=s=n) in equilibrium conditions, which yields to $\frac{A^2}{b}.\frac{n+2}{(3n+4)^3} - f = 0$.

If we rewrite this equation with respect to "n" we obtain, $\frac{n+2}{(3n+4)^3} = \frac{f.b}{A^2}$.

For other MNOs, we can find the profit maximizing number of MVNOs by substituting "n" by "m" and "s" as we assumed that at the equilibrium conditions, the profit maximizing numbers of MVNOs are the same for all MNOs. As a result,

$\frac{n+2}{(3n+4)^3} = \frac{m+2}{(3m+4)^3} = \frac{s+2}{(3s+4)^3} = \frac{f.b}{A^2}$, which means that any positive values of "n", "m", and "s" are the profit maximizing number of MVNOs depending on "f", "b", and "A".