What determines broadband uptake in emerging countries? An empirical study[1]

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Abstract: The conventional wisdom is that income is the most important factor that affects broadband uptake in any given country. However, in this paper we hypothesize that income is not the main factor that affects broadband uptake especially in emerging countries. In addition we prove that unlike the developed countries, the hypothesis that PC per hundred inhabitants is considered a determinant of broadband uptake is not really true when it comes to emerging markets. On the contrary, in emerging countries tele-centers and internet cafes or public point of access are the main ways of access to the Internet on the subscriber lines using broadband. In addition we answer the question of what are the most important factors, other than income, that really influence broadband penetration in emerging countries. This paper is motivated by a paradox in figure one in which the low middle income countries have a higher broadband penetration compared to upper middle income countries. The method of estimation is a new approach as it is applying the method of panel data and fixed and random effects, compared to just OLS usually adopted in other studies, in order to determine the factors that affect broadband uptake in emerging countries. The analysis reveals that these countries which we describe as emerging countries, are characterized by the leapfrog phenomena in the field of ICT which includes broadband access. These countries as they attract a big share of the FDI are really challenged by this opportunity and they utilize leap frog technologies like Asymmetric Digital Subscriber line (ADSL) in order to create an enabling environment to attract and stimulate even more FDI resources.

Keywords: Emerging economies, fixed broadband penetration, panel data, fixed effects, random effects.

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[1] Extract from Ph.D. research work by Mona Farid Badran submitted to Cairo University.
The author is grateful for the comments of the two reviewers of the IFIP9.4. conference.
This is the first academic econometric research study on broadband diffusion in Egypt, other Arab countries and some emerging countries.

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1. INTRODUCTION

Before recent technological developments in telecom the use of available fixed telephone subscriber line was limited to voice telecommunication only. At present the high frequencies on the subscriber line can be used for high speed internet access. This Internet access technology is generally referred to as broadband. A popular example is the ADSL, the Asymmetric Digital Subscriber line for broadband Internet access.

Recently, econometric studies performed to evaluate the uptake of broadband have focused on developed economies like USA and OECD countries. However, emerging economies are playing an increasing role in the global economy. These countries are neither developed or least developed countries. They are a heterogeneous group of countries that have certain characteristics in common. Out of 22 emerging economies used in the sample for this study, 15 economies are among the top 75 countries for broadband penetration per 100 inhabitants (ITU 2006c). Recognizing the importance to transform their economies, these countries have adopted policies to transform their economies from production to knowledge based economies. Broadband uptake was recognized by economists and policy makers as the main vehicle to achieve knowledge based economy. The purpose of this paper is to determine the factors that impact broadband penetration in emerging countries, and to provide policy recommendations to increase broadband uptake in these economies. Specifically, using econometric techniques , this paper attempts to solve the paradox of increased broadband uptake in emerging countries compared to lower penetration rates of broadband in relatively higher income countries as depicted in figure one below.

Building knowledge based economy or e-economy is a goal set by the policy makers in many emerging countries. For example, e-strategies are formulated, and increasing internet access and internet penetration is becoming a main goal that policy makers in these countries are trying to reach. In the latest Internet Report 2006 by International Telecommunications Union (ITU), 15 countries (Lebanon, Qatar, UAE, Bahrain, Argentina, Turkey, Mexico, Malaysia, Brazil, Russia, Kuwait, Uruguay, Morocco, Venezuela, Algeria) out the 75 countries specified as leaders in broadband penetration, are considered emerging countries according to our sample. Their penetration rate ranges from 3.6 to 0.8 penetration rate per 100 inhabitants. In the abovementioned report by the ITU, broadband uptake in lower middle income countries (which some of them fall under the concept emerging economies) is much higher than the upper middle income countries.

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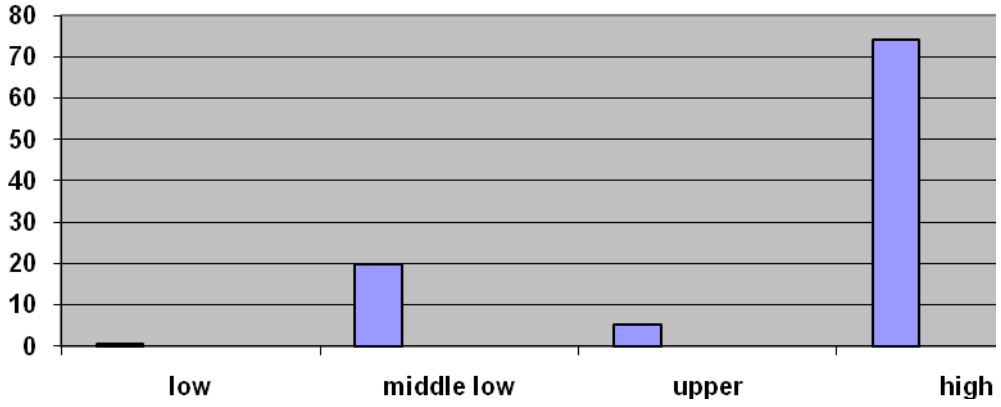
In the following Figure, 1 we notice that the level of fixed broadband uptake in the lower middle income countries is higher than the upper middle income countries.[3] This is considered a paradox since the conventional broadband analysis would correlate income level with broadband penetration meaning that the higher the income of a country the higher the broadband penetration rate of that country. This paper attempts to explain this paradox.

Figure 1: Percentage of fixed broadband subscribers by income 2005



Source, ITU Internet Report 2006c, Digital Life

Emerging markets are characterized by high growth potential, and newly developed financial markets. Examples of emerging markets include Brazil, Malaysia, countries in Eastern Europe, and parts of Africa and the Middle East and MENA Region.

Originally, emerging economies used to refer to a narrow list of middle to higher income economies among the developing countries. It actually encompasses economies with stock markets that allow foreigners to participate in their market activities. These markets are immature compared to those of the world's major financial centers, but are becoming increasingly sophisticated and integrated into international markets. They provide potentially high returns but they are intensely volatile and involve a relatively higher risk compared to established markets.[4]. However, recently the list expanded to include other economies with considerable potential of growth.

1.2 **THE IMPORTANCE OF INCREASING BROADBAND UPTAKE IN EMERGING COUNTRIES:**

The adoption of broadband, whether wire-line or wireless, has been identified by policy makers and economists, worldwide, as the way to achieve the e- economy(Maria Michalis 2001). Thus broadband uptake was carefully analyzed by economists to examine both the

[3] Gross National Income (GNI) per capita of lower middle USD 876–3465, Upper middle USD 3,466–10,725,

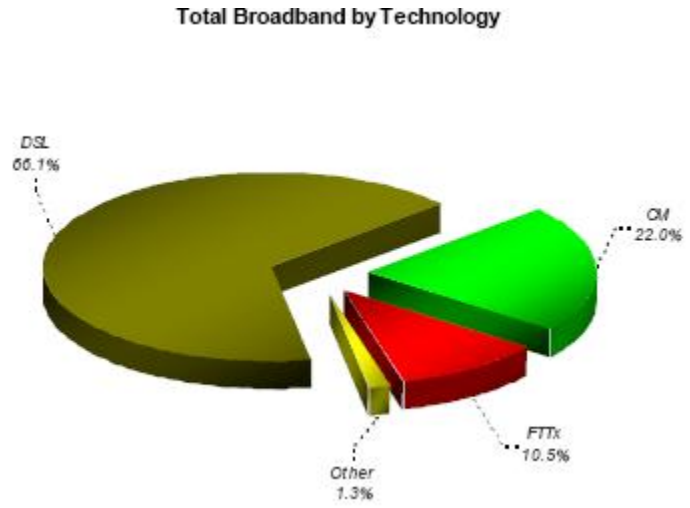
source .ITU " Digital life" 2006 P:9.Notice that the ITU report did not provide a concrete set of countries. However, GNI level was used as a benchmark to determine the set of countries referred to by this report. In our empirical study we adopt a set of emerging countries identified by economists in other research based on the criteria mentioned above.

[4] www.equanto.com/glossary/e.html

actual role that broadband is playing thus far, as well as the factors that affect its uptake. Broadband technologies would help these countries to accelerate their growth by integrating (ITU 2006b) marginal communities into process beyond the geographical limitations of their specific areas. This refers specifically to wireless broadband. Wi -Max technology has been used in Spain and recently in Egypt, for example, among other countries, to connect villages to high speed internet access in a very short time without relying on telephone fixed line network, the public switched telephone network.

The popularity of ADSL among the various broadband technologies is depicted in the following figure:

Figure 2: Total Broadband by Technology



Source: Point Topic limited, Quarterly reports, Quarter1, 2007

Advantages of broadband also include improving and enhancing business productivity in emerging countries, since broadband would help to reduce overall transaction costs and improve the revenue generating potential of businesses. It would also boost the employment rate as well as the GDP growth rate. The Information Technology, IT sector would be a leading sector to the growth in these countries as for example the Republic of Korea, where the growth in IT sector accounted for 50% of the GDP growth rate in 2002(ITU 2005).

The digital divide, especially in terms of rural to urban, is one of the major worries that emerging countries have to deal with. Given the promising progress that these economies are undertaking in terms of high growth rates and active and flourishing stock markets, closing the digital divide and attaining knowledge based economy is an ultimate goal of these countries. Economic development and Social development require devoting great attention to the importance of laying down the foundation of the new, knowledge based economy with all the benefits that comes with such a new paradigm.

1.3. FIXED BROADBAND UPTAKE AND E-STRATEGIES IN THE EMERGING COUNTRIES:

The importance of broadband lies in the e-strategies adopted by the emerging countries in order to induce demand for the high speed internet access. These strategies may include the killer application that would attract people to connect to the internet using broadband

technologies. These strategies include e-government, e-health, e-learning etc. E-Strategies are vital as they empower local communities to shaping a future that is based on Information and

Communication Technologies (ICT) and e-applications. This would assist in achieving sustainable development toward a knowledge based economy or e-economy. E-strategies are consisted of the following elements: ICT applications or e-applications, E-legislation, Internet protocol, Multipurpose community telecenters (MCT), Cybersecurity, ICT awareness, Empirical studies show that broadband subscribers do increase their online research of health information (Kolko 2007). We notice that e-applications are the one dominating the widespread use of e-strategies. In particular e-government seems to be the killer application according to the ITU report (ITU 2006a).

2. LITERATURE REVIEW:

Bauer et *al* (2003) investigate broadband diffusion in the OECD countries. The sample consisted of the 30 OECD countries for the year 2001 and the method of estimation was Ordinary Least Square (OLS).

The empirical model consisted of a simple cross- sectional design based on the observations for the year 2001. The method of estimation was a multivariate OLS regression method to estimate the model parameters. Broadband Penetration is the dependent variable, the independent variables include price of broadband, the price of dial-up service, income as GDP per capita measured in US$, preparedness that reflects the mobile/Internet index which is calculated using the ITU Internet Report, the intensity of local competition, population density and dummy variable reflecting policy regimes like unbundling, cable-teleco cross ownership, and government funding to support broadband. The authors used cluster analysis to identify countries with similar policies and arrange them in homogenous subgroups of countries, in order to reduce the number of independent variables. The membership in these clusters, mainly three, was translated into a dummy variable, used in several of the empirical models. Five models with different specifications, were estimated.

The preparedness of countries to adopt broadband is an index measuring factors such as the attitude of a nation towards advanced information technology, and the availability of complementary technologies, such as computers, (which is a calculated index of Mobile/Internet).

Ferreruela and Alabau-Munoz (2004) took this methodology a step further, as they studied all three relationships, supply, demand and adoption of broadband. There was a breakdown of the factors forming the supply, demand and penetration of broadband. Groups of variables were formed as they were classified as supply side and demand side and broadband penetration. It uses a comprehensive panel dataset from 30 OECD countries. The period of observation for this study is from 2000-2002. Pooled regression technique was implemented.

Supply side factors:

These are factors that indicate the availability and development of telecommunications services in a country. The groups of indicators are: Group 1: infrastructure availability; Group 2 : infrastructure investment; Group 3 : market competition; Group 4: prices

Demand side factors:

These are factors that characterize the inclination of the society to adopt telecommunications services, including broadband. This group's indicators are: Group5: Telecommunications services penetration; Group6: Internet indicators; Group7: Economic indicators; Group8: Demographic indicators Group; 9: Education; Group 10: Social indicators; Group 11: Broadband Penetration

The indicators that represent **broadband penetration** are given in the *group 11 that represent the number of DSL subscribers per 100 inhabitants. It consists of indicators from both supply and demand.*

The underlying models for broadband supply, demand and penetration at a national level are represented as follows:

BSn = f(X1,X2,….,Xn), where BSn is Broadband supply side

BDn= g(Y1,Y2,…..,Yn) where BDn is broadband demand side

BPn=h(X1,X2,….,Xn, Y1,Y2,…..,Yn) where BPn is Broadband penetration.

Applying the condition that must be fulfilled at market equilibrium , which is BSn=BDn, we obtain the broadband penetration rate BPn.

Martha Garcia-Murillo and David Gabel (2003) investigated the demand for broadband in 135 heterogeneous countries in 2002 using OLS and logit models as well. The study aimed at finding out the optimal policy for promoting broadband services.

In this analysis, the first hypothesis is that Broadband subscription is positively related to the privatization of the incumbent carrier. The second hypothesis is that broadband subscription is positively related to the availability of domestic content.

Distaso *et al*.(2006) addressed another factor of broadband adoption, namely the effects of *inter platform* competition, i.e. competition between alternative platforms such as T.V. cable access, fiber optic cable, high speed Internet access, and *intra platform* competition, which is competition between different providers of the Digital Subscriber Line(DSL) segment of the market. Data from 14 European Countries over four years were obtained. These are all EU countries except Greece (due to lack of data). Each country was observed in quarterly time intervals during the period starting from the 4th quarter of year 2000, until the second quarter of 2004. These constituted 15 time periods. Three models were estimated using well known panel data techniques. (Notice that there is another set of Literature dedicated to measure the effect of various policies on broadband uptake in developed countries, which is given in the appendix)

The contribution of this paper is to present an econometric analysis of broadband adoption in emerging countries. The results obtained in this research will point out exactly the determinants of broadband uptake in the considered set of countries (namely (Algeria, Argentina, Bahrain, Brazil, Colombia, Jordan Kuwait, Lebanon, Malaysia, Mexico, Morocco, Oman, Qatar, Russia, Saudi Arabia, Syria, Tunisia, Turkey, Egypt, UAE, Venezuela, and Uruguay). We construct a panel data set and apply the method of fixed effect to determine these determinants. In addition using the standardized beta coefficients we are able to clearly identify the most important factors or determinants of broadband uptake in these set of countries based on the panel data set. In contrast with applying the method of OLS or logit regression used in many studies like in Bauer et al. and Ferreruela et al., we apply in this

research the method of fixed effects to account for the possible omitted variables in this kind of research.

3. THE EMPIRICAL STUDY:

3.1 Data Description:

Economic indicators include data for ***Gross Domestic Product per capita*** (**GDP per capita)** in current prices ($), GPD per capita using the PPP method and the GNI per capita. These were obtained from the Eurostat website. GNI comprises of the total value of the goods and services produced within a country and income received from other countries (interest and dividends), less similar payments made by other countries. The PPP method is the purchasing power parity method. An economic theory that estimates the amount of adjustment needed on the exchange rate between countries in order for the exchange to be equivalent to each currency's purchasing power.

Infrastructure indicators: Main fixed subscriber lines per 100 inhabitants (Teledensity). Fixed lines are telephone mainlines or landlines connecting customer's telephone to the public switched telephone network, the data were obtained from the ITU database.

Internet penetration indicators: Internet host (ITU 2006d) refer to the number of computers directly connected to the worldwide Internet network. Note that Internet host computers are identified by a two-digit country code or a three-digit code generally reflecting the nature of the organization using the Internet computer. The number of hosts is assigned to economies based on the country code although this does not necessarily indicate that the host is actually physically located in the economy. In addition, all other hosts for which there is no country code identification are assigned to the United States. Therefore the number of Internet hosts shown for each country can only be considered an approximation. Data on Internet host computers are obtained from Internet Software Consortium and RIPE (Réseaux IP Européens).

Internet *User per 100 inhabitations* is based on nationally reported data. In some cases, surveys have been carried out that give a more precise figure for the number of Internet users. However surveys differ across countries in the age and frequency of use they cover. The reported figure for Internet users—which may refer to only users above a certain age—is divided by the total population to obtain ***users per 100 inhabitants*** *(times hundred).*

PCs shows the estimated number of Personal Computers in terms of **PCs per 100 inhabitants**. The figures for PCs come from the annual questionnaire supplemented by other sources. Again, this could not reflect the actual usage of PC's in these set of countries as explained below.

International Internet bandwidth measured in Mbps, refers to the capacity which backbone operators provision to carry Internet traffic measured in bits per second. This indicator is intended to represent the *quality* of the experience of Internet users within a country. If the experience of an Internet user in a country is poor, because of slow speed, then either people will not use ICTs, or they will not be able to use them effectively and creatively. In many developing countries, most Internet access is to sites abroad and therefore the amount of international bandwidth has a major impact on performance (ITU 2005).

In addition the **price of local call P(t-1)**was added in estimating the model lagged by one time period, as a proxy for the price of substitute(dial up).

Z_{it} refer to the unobserved variable that varies from country to another but does not change over time e.g.: cultural differences toward broadband penetration.

3.2. The Theoretical model:

The structural model for the local level of broadband penetration can be represented by:

qD = f (price of the commodity, price of substitutes, price of complementary, income, (shift factors))

qS = f (price of the commodity, cost conditions, income (shift factors))

The equilibrium condition is qD = qS , where qD the local demand for broadband and qS is the local supply. To derive the national level of broadband demand and supply, an aggregation rule on the national level was utilized, which is the following:

- $QD = \Sigma i\ qD$
- $QS = \Sigma i\ q\ S$
- **QD = QS This condition provides the actual level of broadband penetration.**

Broadband penetration per 100 inhabitants represents the technology of ADSL which is currently broadband technology available for users in emerging countries included in our sample. Fixed effect model will be used to identify the main factors influencing broadband supply, broadband demand and broadband penetration.

The reduced form models of BSn, BDn, BPn were translated into the following empirical form models.

$$BSn = \alpha_0 + \Sigma\alpha_i x_i + \varepsilon$$

$$BDn = \beta_0 + \Sigma\beta_i y_i + \varepsilon$$

$$BPn = \gamma_0 + \Sigma\alpha_i x_i + \Sigma\beta_i y_i + \varepsilon$$

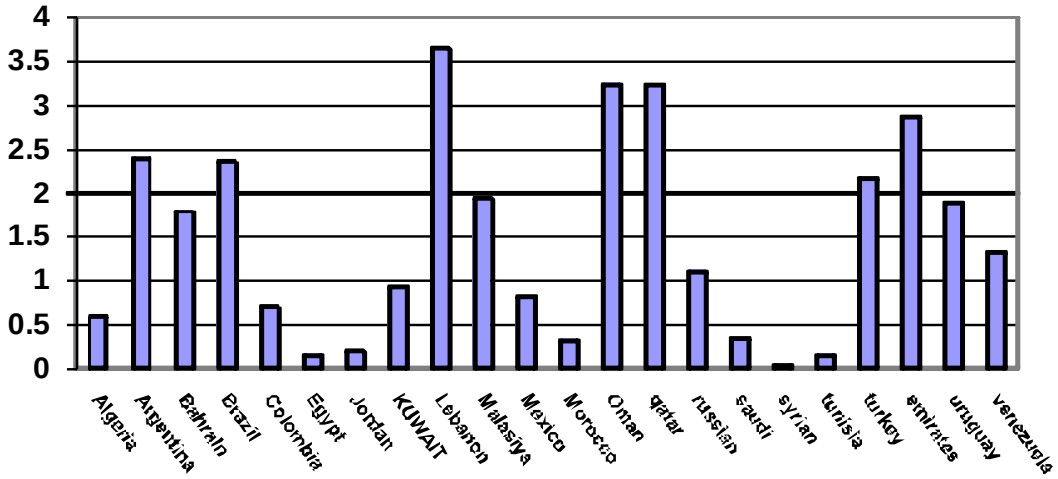
Where BS is supply of broadband, BD is the demand for broadband, BP is the level for broadband penetration.

Due to this aggregation rule, the aggregate supply and demand relations remain functions of the prices and the competitive conditions etc. However, at the national averages level, we have:

Q = f (GDP per capita, tertiary school enrollment, population density, number of pcs per 100 inhabitants, internet hosts, number of main fixed line, number of internet subscribers, price of local call P-1). These factors include both supply and demand side factors of broadband penetration.

This methodology was developed by Bauer *& al* (2003) in investigating broadband diffusion in OECD countries.

Figure 3: Total broadband penetration per hundred inhabitants in 2005



Note: The ITU broadband penetration rate per 100 inhabitants is misleading e.g. for Egypt, since it does not include the effect mass usage such as internet cafes into consideration, moreover it neglects the social structure of the population since e.g. 40% of inhabitants in Egypt are rural population with very limited exposure to IT.

The empirical model is constructed as follows:

$$BP_{i,t} = CONS + \beta_1 INC_{i,t} + \beta_2 SCHOOL\ ENROL_{i,t} + \beta_3 PCS/100_{i,t} +$$

$$\beta_4 INTERNET\ USERS_{i,t} + \beta_5 POPD_{i,t} + \beta_6 FIXED\ LINES/100_{i,t} + \beta_7 HOSTS_{i,t} + \beta_8$$

$$P(t-1)_{it} + \beta_9 z_i + \varepsilon_{i,t}$$

where $\varepsilon_{i,t} \sim (N, \sigma)$ iid (identically, independent, distributed errors)

Where : BP is the dependent variable and refers to Total broadband per 100 inhabitants which is a measure for broadband penetration , CONS is the intercept (constant), INC is income as GDP per capita measured in US$, SCHOOL ENROL refers to the percent the population that have obtained tertiary education. Demographic indicators: POPD is population density Population *Density* is based on land area data from the UN.

The methodology used is performed as follows:

1. **Pooled OLS estimation method** (Greene 2003)**:**

The first attempt is to construct a multiple regression model and estimate it using OLS, this is the pooled OLS technique. This method pools or combines all the time series or cross section data and estimate the underlying model using OLS.

$$BP_{i,t} = CONS + \beta_1 INC_{i,t} + \beta_2 SCHOOL\ ENROL_{i,t} + \beta_3 PCS/100_{i,t} + \beta_4 INTERNET\ USERS_{i,t} + \beta_5 POPD_{i,t} + \beta_6 FIXED\ LINES/100_{i,t} + \beta_7 HOSTS_{i,t} + \beta_8 P(t-1)_{it} + \beta_9 INT\ Band_{it} + \varepsilon_{i,t}$$

Where n=88

This model assumes that both the constant term and the estimated coefficients are fixed. Another assumption is that $E(E_{it},E_{jt})=0$. All the classical assumptions hold for the error term (spherical disturbances).The degrees of freedom are nt-k. Thus the number of degrees of freedom is high and this means more efficiency. This is the most restricted model and the most elementary pooling technique. However this model does not include the effect of time nor the effect of country over the cross section data or groups that constitute the sample.

2. Fixed effects model:

This is another way to overcome the problem of omitted variables in a panel data where the omitted variables vary over across entities (countries) and over time. The obtained estimated coefficients are called the within estimators because it uses the time variation within each cross section.

We can determine whether pooled OLS or fixed effect model by using the F- test. Where the null hypothesis indicates that there is a common intercept. Thus the pooled OLS would be the appropriate model while not accepting the null would indicate that the intercepts are not the same, thus we have to use fixed effects to estimate the model.

The Fixed effects model for broadband penetration is the following:

$$BP_{i,t} = CONS + \beta_1 INC_{i,t} + \beta_2 SCHOOL\ ENROL_{i,t} + \beta_3 PCS/100_{i,t} + \beta_4 INTERNET\ USERS_{i,t} + \beta_5 POPD_{i,t} + \beta_6 FIXED\ LINES/100_{i,t} + \beta_7 HOSTS_{i,t} + \beta_8 P(t-1)_{it} + \beta_9 z_i + \varepsilon_{i,t}$$

Notice that this method requires the addition of dummy variables for time effects and for country effects, in order to capture the unobserved heterogeneity across countries and over time. This method is called least square dummy variables model (LSDV). Then we apply OLS to this model and we would obtain consistent unbiased estimators for β's.

The Least Square Dummy Variable Model: (Lsdv)

We introduce the dummy variables that allow the intercept term to vary over cross section units, only.

$$BP_{i,t} = CONS + \beta_1 INC_{i,t} + \beta_2 SCHOOL\ ENROL_{i,t} + \beta_3 PCS/100_{i,t} + \beta_4 INTERNET\ USERS_{i,t} + \beta_5 POPD_{i,t} + \beta_6 FIXED\ LINES/100_{i,t} + \beta_7 HOSTS_{i,t} + \gamma_2 D_{2i} + \ldots\ldots\ldots\ldots + \gamma_{23} D_{23i} + \varepsilon_{i,t}$$

where D_{ni} denotes the dummy variables or binary variables that are equal one when i=1 and in this case it is Egypt (base group) and equals zero otherwise.

2. **The Random Effect Model:**

This is also called the error –component model, where the error term includes cross section error component, time series error component and combined error component.

We also assume that the individual error components are uncorrelated with each other, and they are not auto-correlated. This model includes observable and non observable effects. This model describes the lack of knowledge through the disturbance term. The advantage of the random effect model is that it is a cure for the loss of degrees of freedom found in the model of LSDV.

3. Fixed vs. Random effect: The Hausman Test:

To choose between the two models, we performed a Hausmann specification test of the null hypothesis of the random effect model in comparison to the alternative hypothesis of fixed effect follows a chi-square distribution.

We will estimate the pooled regression with no fixed effects, then calculate the F-test. This is followed by estimating the fixed effects model (within model) and the individual country effects, the LSDV model. Finally, we estimate the random Effects Model and Hausman test.(see appendix for more details)

4. ANALYSIS OF THE RESULTS:

In general, the obtained results from table 4 are consistent with the previous literature discussed earlier concerning broadband uptake in developed countries. Compared with previous studies that discuss factors i.e. indicators affecting broadband penetration we find that common factors or indictors used in previous and the present study include population density, internet subscribers, price of dial up, school enrollment, sites are found to be statistically significant. New indicators were added namely, PC/100 and fixed main lines /100 inhabitants. (See table 7)

In Table 4 of fixed effects models for broadband penetration , *GNI per capita* is the right measure for income, and is statistically significant in model 3, meaning that the higher GNI per capita in the emerging countries the more the penetration of broadband take place. The GDP per capita measure for the income variable is not statistically significant and economically not significant as well. An explanation to this result is found in the study of democracy and interconnectivity based on simultaneous equations analysis growth in Internet nodes, by Kedzie (1997). In his study "statistical test results do not support…economic development as a confounding third variable… neither democracy nor GDP proves to influence interconnectivity strongly". Another explanation of the statistical and economic insignificance of GDP per capita is that in the countries included in the sample, the officially reported income is very small compared to the actual earned income to individuals especially government employees . In addition the informal sector in these economies is relatively large.

The *population density* is statistically significant which is also coinciding with a priori expectations, and it means that in densely populated areas it is much easier to connect people to the internet and broadband.

Furthermore, the more people are exposed to the internet, the more the uptake of broadband will increase as the *internet users* variable in all the three models are statistically significant. These users are more likely to be appreciative of the benefits and advantages of high speed internet access. This is consistent with the previous literature that emphasizes the importance of internet exposure in increasing internet penetration rate.

School enrollment especially the tertiary level of education is a significant determinant of the broadband uptake in these countries. Although some reports indicate that basic literacy indicators should serve as an appropriate measure for the population ex ante capability for Internet access, which includes broadband penetration. However, we argue that the level of education indicates the exposure to the language as well as sophistication in thinking which is a prerequisite to be able to navigate on line and benefit from on line activities. According to GlobalReach (UNCTAD 2006), 43 per cent of online users and 68.4 per cent web content use English, down from the 80 per cent of English language web pages in the late 1990s. Thus in depth human development indicators like the level of tertiary education is necessary variable to control for when studying the broadband penetration in emerging countries especially in Arab and emerging countries.

Number of Fixed Main lines per 100 inhabitants or Teledensity are considered the infrastructure requirement for broadband penetration in any country, especially the wire line broadband is statistically significant, as it plays a major role as a determinant of broadband penetration in the countries under study. Moreover, this is consistent with a priori expectations and the literature as well.

The present PC's per hundred inhabitants indicator is statistically insignificant and with the wrong expected sign which needs a different methodology for its calculation. As a matter of fact, access to a PC depends mainly in emerging countries on the popularity of low cost Internet cafes and other public point of access that daily attracts hundred of users at a very low cost. This requires a special study to assess its true value.

The variable controlling for the number of *internet hosts* is becoming statistically significant in the last model at a 1% level of significance. This is consistent with the fact that an increasing number of Internet hosts implies increased ability to handle, service and store large amounts of data. The hypothesis tested by the Martha Garcia (2003) whether the local internet hosts are determinants of broadband penetration, and the empirical study indicated that it is not statistically significant. This means that it is not the local number of internet hosts rather the international number, because according to the UNCTAD Report 2006 the internet hosts are commonly registered in generic top-level domains like *com*, *org*, *net* or *edu* rather than country domains like *cl* or *us*, and the statistics are based on these top level domain names. Furthermore, people in low-income countries who wish to reach a global audience have an incentive to place content on servers in high-income countries with fast, reliable connectivity at relatively low prices. This method may even improve domestic access.

The *price of 3 minute local call* is used as a proxy for the internet access charges for dial up not broadband. This is due to the lack of data on time series data for rates on internet access specifically broadband.

We included this proxy in the model as the price of the substitute which is the dial up internet access. As the price of this mode of access to the internet becomes less expensive, the demand on dial up access will become more popular versus the broadband access, and broadband penetration rates could be adversely affected.

To overcome the problem of endogeneity which is inherent characteristic in any model that controls for prices, we utilize the lagged variable of the price of local call, lagged one year in our model.

There are however certain limitations on this proxy[5]. For Example: Charges may be fixed or flat rate regardless of call duration. There could be price discrimination or off peak and peak pricing or the rate could differ whether the call is for Internet access; and finally, operators may provide discounted calls to user-specified numbers. The estimated coefficient is statistically significant, with the right sign consistent with a priori expectations. When the price of dial up increases, broadband service becomes more attractive and people switch to broadband, ceteris paribus. This can be referred to as the "switching effect"(Flamm et al 2005).

The R-squared as a measure for the goodness of fit of how much of the variations in dependent is explained by the variations in the independent variables. In our fixed effect model number 3, the R-squared relevant in these models is the within R-squared and it has all the properties of the overall R-squared. The within estimator maximizes the R-squared within. In the three models chosen, the within R-squared is relatively high indicating that the explanatory variables explain much of the variation in the dependent variable. We notice that when we controlled for income using the GNI per capita in model 2, the R –squared within improved, indicating that the these set of explanatory variables do explain better the changes in broadband penetration in these set of countries.

As to the paradox which was presented in figure one of fixed broadband penetration in lower middle income countries, from abovementioned analysis we can conclude that this set of emerging countries have some characteristics of the developed countries, in addition to some other idiosyncratic characteristics. Actually, population density of these countries as well as their Internet user rate outweigh the negative or no effect that their relatively low income might exhibit on broadband adoption. *In addition,* it manifests really the leapfrog phenomena that the emerging countries are experiencing when using the new technologies like ADSL, using high speed Internet access instead of just dial up service to connect to the Internet

Furthermore, these countries are target to many multinational companies and attract a substantial amount of FDI. This stimulates the economy and compels the market players to adopt the latest technologies, namely fixed broadband on subscriber line to benefit the most from these new investments. The successful role that is played by e-applications like e-commerce and on line banking as well as e- government in these set of countries contribute to the enhancement of broadband uptake in them. Among the advanced services that use fixed broadband is video conferencing and teleworking.

It was found that School enrollment was the most important indicator affecting broadband uptake in these set of emerging markets. This no surprise since the computer illetracy rate is high and the generation that was exposed to the computer at school is the one who is using the Internet, and in this regard the high speed internet access. One important conclusion from the above analysis is that despite that broadband uptake is related GNI per capita as in the developed countries, this doesn't really seem to be the dominating factor that affects broadband uptake in these countries. Rather school enrollment and population density and Internet user rate drive the increase in broadband penetration in these set of countries.

5. LIMITATIONS OF THE STUDY:

The study provides a positivist's view of broadband uptake not taking into consideration the broadband uptake could be affecting some of the mentioned factors as well, i.e. it could be considered a two way relationship between broadband uptake and its determinants.

6. CONCLUSIONS AND POLICY RECOMMENDATIONS:

From the economic perspective, it seems obvious that broadband penetration is determined by the controlled variables, also called indicators, that are referred to in the literature and theory. However, in this paper we have proven that income is not the most important factor determining broadband uptake in the emerging countries. This is due to the leapfrog phenomena that characterizes these countries and that the externalities and spillover effects that is related to ICT diffusion, and to the increased presence of FDI in the emerging countries. In addition, although the positive relationship between PC per 100 inhabitants and broadband uptake is expected and exists in developed countries, in the case of emerging countries, the independent variable PCs per 100 inhabitants, given by ITU cannot be considered as a true value and hence does not give the true effect on broadband penetration. A different method to assess the actual value of this indicator in emerging countries is needed that would take into account the public usage of broadband internet access at low cost, such as internet cafes, schools, clubs and public libraries. Other factors/ indicators that seemed to impact broadband uptake in these set of emerging countries other than income include tertiary education and population density.

It is found that the deployment of more fixed main lines would increase broadband penetration. Thus governments should expand the existing public switched telephone network and utilize the latest technologies in this field. Furthermore, governments can explore the option of leasing the subscriber lines to competitors to open new markets for potential entrants in this telecom market segment. The issue of "build or buy" has caused a big debate among Telecom economists and policy makers regarding the advantages and disadvantages of allowing service based competition like local loop unbundling. Governments in these countries should definitely explore the option of service based competition more seriously. A set of policies like tariff rebalancing, collocation and interconnection arrangements should be addressed before the commencement of the unbundling of local loop policy.

Countries with high population density, should find it easier to increase broadband uptake compared to population that is scattered like in rural areas ceteris paribus. This is due to the fact that a large number of people would be connected to the telephone exchange and thus it would be easier to a new entrant to lease the local loop from the incumbent telephone company and install his new additional (ADSL) equipment. In densely populated areas, i.e. urban areas, the distance between the local exchange and the subscriber i.e. the subscriber line is short which allows a better quality of broadband service to the end user.

The set of countries that constitute our sample in this research are unique in that they are the target of many FDI (foreign direct investments) and thus steps are taken toward transforming these economies to new economies by finding incentives to increase broadband uptake. This approach is considered an important signal to these new investors. Measures taken to accelerate this process would indicate how serious these economies are in entering the new paradigm of knowledge -based economy.

Thus it is imperative to determine exactly what enhances broadband penetration, especially given the idiosyncratic features of emerging economies.

Further empirical research is necessary to evaluate the policies implemented so far by governments in these countries, such as subsidy choices on both the demand side and the supply side. The percent of population living in urban areas and the language of the content, like the arabization of websites to induce non English speaking people to use the Internet are significant, and thus can increase the chances of broadband penetration. Market structure of telecom sector could also be controlled for in the following new studies. Thus, with the increase of available data, more profound empirical research by economists will be fruitful for these countries in the future.

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Appendix:

Table 1: Description of the Variables and their expected signs:

	The control variables	**Description of the variable**	**The expected signs A priori**
Economic Indicators	INC	GDP per capita measured in US$ or GDP per capita using PPP GNI per capita	Positive
Education Indicators	SCHOOL ENROLLMENT	% of population who have completed their tertiary education	Positive[6]
ICT Indicators	PCS/100	Pcs per hundred inhabitants	Positive
Demographics Indicators	POPD	Population density in square km	Positive
Internet penetration Indicators	INTERNET USERS	**Internet *User per 100 inhabitants***	Positive
Infrastructure Indicators	FIXED LINES/100	main telephone lines (fixed lines) per 100 inhabitants	Positive
Internet penetration Indicators	HOSTS	number of computers directly connected to the worldwide Internet network	Positive
Prices Indicators (price of dial up a substitute for	P-1	Price of a 3-minute fixed telephone local call (peak rate telephone – US$) one year lagged	Positive

[6] This hypothesized relationship is made by Gabel and Kwan (2000) and Madden, Savage, and Simpson (1996). Both studies uncover the anticipated coefficient, however, only the latter study finds a statistically significant relationship.

BB)			
Capacity of the Internet	International bandwidth	International Internet Bandwidth (Mbps)	Positive
Broadband indicators	**Dependent variable** BP	Broadband penetration per 100 inhabitants	----------

Table 2: Summary Statistics:

Variable	Min	Max	Mean	Standard deviation
GDP per capita ($)	1.775	431110	7556.554	8979.485
GNI per capita ($)	1110	30630	6754.148	6831.16
SCHOOL ENROLLMENT (%)	9.95	70.67	30.52409	14.40877
PCS/100	1	75	38.94318	21.28048
POPD	1	56	27.30682	16.11621
INTERNET USERS	1.59454	42.36923	12.85715	8.815323
FIXED LINES/100	2.822633	30.95388	17.4811	7.828698
Internet HOSTS/	1	63	31.61364	19.2649
P-1 ($)	0	0.2452316	0.0627284	0.0591719
International bandwidth (Mbps)	16	29200	3646.21	6148.705
BP	0	3.634331	0.6400611	0.8214905

Table 3: Regression Results of Pooled Ordinary Least Square:

Dependent variable broadband penetration rate per 100 inhabitants:

	Model 1	Model 2	Model 3	Model 4
INC	GNI_per_100 -0.0006 (0.0012)	GNI_per_100 0.0001 (0.013)	GDP_per_100 0.0004 (0.001)	GDP_per_100 0.00106 (0.001)
SCHOOL ENROLLMENT	0.0084336 (0.006)*	0.0189071 (0.007)**	0.199 (0.072)***	0.022 (0.008)**
PCS/100	-0.0000554 (0.003)	-0.001424 (0.0037)	-0.0012959 (0.004)	-0.0023106 (0.004)
POPD	-0.0064313 (0.005)	-0.0018035 (0.005)	-0.0018 (0.005)	0.00214 (0.006)

	Model 1	Model 2	Model 3	Model 4
INTERNET USERS	0.045351 (0.010)***	0.0375 (0.106)***	0.0375 (0.10)***	0.0337 (0.113)**
FIXED MAIN LINES/100	0.259948 (0.112)**	0.220885 (0.112)**	0.0204 (0.115)*	0.017083 (0.131)
INTERNET HOSTS	-0.0008898 (0.005)	-0.00160 (0.0046)	-0.0019 (0.0046)	-0.0017461 (0.005)
PRICE OF DIAL UP T-1		2.104908 (1.216)*	2.19782 (1.231)*	1.9448 (1.29)*
INTERNATIONAL BANDWIDTH				0.0000305 (0.001)***
CONSTANT	-0.4057278 (0.277)	-0.748408 (0.3059)**	-0.77363 (0.29)**	-.9844256 (0.351)**
N	88	84	84	70
F-statistic	9.10	8.55	8.59	6.55
P >(F-statistic)	0.00	0.00	0.00	0.00
R-squared	0.44	0.47	0.47	0.49

Standard Error between brackets.

* significant at 90% significant level

** significant at 95% significant level

*** significant at 99% significant level

Table 3 represents the Pooled Ordinary Least Square regression (OLS) which was performed for 4 models that we estimated. In this research, the difference between the 4 models are in the independent variables that we controlled for in each one, in addition to whether we controlled for GNI per Capita or GDP per Capita in the model. Standerdized Beta coefficients were also calculated in order to be able to compare and determine which of the independent variables (indicators) affect broadband penetration the most. The four models were all statistically significant as the P-value of the F-statistic was zero. GNI per Capita and GDP per capita were divided by hundred in order to facilitate the interpretation of the regression models. The latter was not statistically significant in all four models. On the other hand, school enrollment, Internet users were statistically significant in all four models, which is consistent with Ferreruela and Alabau (2004). Price of dial up lagged one time period was statistically significant when controlled for. In addition the International bandwidth was significant. These all are consistent with the literature.

The calculation of beta coefficient is regarded as an important addition to the analysis, as it indicated that Internet users is the most important factor that affects the uptake of broadband,

followed by school enrollment. Finally fixed main lines and international bandwidth have also an important impact on broadband penetration this appears in the less restricted model that includes international bandwidth. Then fixed effects model, table 4 and Random effects model table 5 were estimated. Then two tests were employed to decide whether fixed effects (FE) or random effects (RE) should be applied. First the LM test is performed to assess whether the estimates of OLS model without country effects, based on pooling the data, are consistent, or there are specific country effects that should be incorporated into the estimation by using suitable procedure such as RE. Second, Hausman test is used to compare the FE and the RE models. Both tests are significant at 0.05 level and thus the FE model cannot be rejected in favor of OLS and RE models. In table 3 the OLS results were reported and in table 4 FE estimates were reported.

The Hausmann test was performed, with Ho: random effect model and

H1: no random effect model. The P value of the X^2 test is 0.000 which means that we cannot accept the null hypothesis and that the model is not a random effect model. Taking the LM and the F test into consideration, we can conclude that the fixed effect model is the appropriate model to implement.

Along the fixed effects models, F-test was performed to test the null hypothesis of common intercept. According to the results, we cannot accept the null hypothesis and the fixed effect model is again the right model, which is consistent with the literature.

Since the calculated F-test is less that the F- tabulated, the conclusion is to reject the null hypothesis of common intercept and to use the fixed effect model as the intercepts are different over cross section units

Table 4: Dependent variable BP per hundred inhabitants:

Fixed effects model

	Model 1	Model 2	Model 3
INC	Gdp per capita 0.000021 (0.00003)	Gni_per capita 0.000065 (0.00004) *	Gni_per capita 0.00005 (0.00004)
SCHOOL ENROLLMENT	0.065 (0.031) **	0.69 (0.0313) **	0.05 (0.28) *
PCS/100	-0.01 (0.004)	-0.005 (0.0038)	-0.0018 (0033)
POPD	0.01 (0.004) ***	0.011 (0.004) ***	0.013 (0.004) ***
INTERNET USERS	0.09 (0.026) ***	0.08 (0.27) ***	0.095 (0.024) ***
FIXED MAIN LINES/100	0.079 (0.034) **	0.09 (3.0) ***	0.08 (0.036) **
INTERNET HOSTS	0.009 (0.006)	0.009 (0.006)	0.01 (0.006) *
PRICE OF DIAL UP T-1	2.05 (1.101) *	1.62 (0.945) *	
CONSTANT	-4.45 (0.807)***	-4.9375 (0.869)***	-4.47315 (0.946)***
N	84	84	88

R-squared within	0.7130	0.722	0.697
F-statistics	11.52	13.61	12.11
P> F statistics	0.000	0.0000	0.0000
F-test P> F	7.21 0.000		

Between brackets are the standard errors. The within estimators have hetroscadastic robust standard errors.

* significant at 90% siginifcant level

** significant at 95% significant level

*** significant at 99% siginificant level

Table 5: Random Effects, LM test and Hausman Test:

	Model 1	Model 2	Model 3
INC	Gdp per capita_100 0.0014 (0.0013)	Gni_per capita_100 0.0006 (0.00214)	Gni per capita_100 -0.00008 (0.00224)
SCHOOL ENROLLMENT	0.0312 (0.014) **	0.0286 (0.015) **	0.01496 (0.0103)
PCS/100	-0.004 (0.0035)	-0.0035 (0.0035)	-0.0020 (-0.003)
POPD	0.004 (0.0038)	0.00397 (0.00397)	0.0012 (0.004)
INTERNET USERS	0.065 (0.17) ***	0.0689 (0.0189) ***	0.075 (0.173) ***
FIXED MAIN LINES/100	-0.0005 (0.018)	0.0033 (0.018)	0.0072 (0.0188)
INTERNET HOSTS	0.0028 (0.0056)	0.0038 (0.0054)	0.0047 (0.0049)
PRICE OF DIAL UP T-1	2..11 (1.976)	2.0144 (1.943)	
CONSTANT	-1.393 (0.4231)***	-1.377 (0.443)***	-1.013243 (0.3666)***
N	84	84	88
R-squared	0.4415	0.4406	0.3935
Breusch Pagan LM test	6.25		
Hausman Test	66.79		

The estimators have hetroscadastic robust, standard errors.

* significant at 90% significant level

** significant at 95% significant level

*** significant at 99% significant level

Table 6: The least square dummy variable model: (LSDV)

	Model 1
INC	GDP _ PER _100 0.0014 (0.003)

SCHOOL ENROLLMENT	0.05 (0.025) **
PCS/100	-0.016 (0.003)
POPD	0.01 (0.006) **
INTERNET USERS	0.102 (0.020) ***
FIXED MAIN LINES/100	0.068 (0.0399)*
INTERNET HOSTS	0.010 (0.006)*
PRICE OF DIAL UP T-1	2.05* (1.86)
CONSTANT	-2.858 (0.769)***
N	88
R-squared	0.8482
F-statistics	11.77

Country Individual Effects

Algeria	1.038607 (0.453)**
Argentina	-2.60719 (0.9766527)***
Bahrain	-2.009598 (0.9154849)**
Brazil	-0.1114034 (0.8424158)
Colombia	-0.697141 (0.6824453)
Jordan	-1.470616 (0.489608)***
Kuwait	-1.583238 (0.8126848)**
Lebanon	-0.9131862 (0.7388813)
Malaysia	-3.995006 (0.8472238)
Mexico	0.2486153 (0.3703413)
Morocco	0.4591973 (0.6870918)
Oman	-1.418148 (1.172587)

Qatar	-1.8596 (1.194793)
Russia	-3.20506 (0.9463197)***
Saudi Arabia	-0.6767447 (0.5422591)
Syria	0.1469914 (0.5853474)
Tunisia	-0.3630942 (0.4436462)
Turkey	-1.78378 (0.9984924)**
UAE	-3.050677 (1.073251)***
Uruguay	-2.825692 (1.06753)***
Venezuela	-0.5968216 (0.4726513)

Table 7: Factors (Indicators) affecting broadband, comparison and summary

Independent variable (indicators)	**Previous study Bauer**	**Previous Study Ferreruela**	**Arab & Emerging Countries**	**Comment**
1.Income GNI /capita	Significant/not significant		Significant	In 5 models Depending on the model
2. School Enrollment		Significant	Significant	
3. Population density	Significant	Not significant	Significant	
4. Fixed lines /100			Significant	
5. Internet hosts		Not Significant	Significant/ not significant	In 3 models Depending on the model
6. Price of local call(dial up)	Significant		Significant	
7. PC/100			Is not a reliable indictor	
8. Internet users		Significant	Significant	

Legend

For Arab and Emerging countries, ITU statistics is the main source.

Panel data for 22 countries from the years 2002-2005. Fixed effect model.

Bauer &al: 30 OECD countries for year 2001.

Ferreruela &al: 30 OECD countries for the years 2000-2002.

Notes:

1.Bauer *& al* used other indicators that include: price of broadband, preparedness, competition and dummy variable for policy regimes.

2.Ferreruela *&al* used other indicators that include available bandwidth per $, lagged variable of DSL enabled Local loop, Unbundled local loop/100 access lines, monthly price of internet access and % of homes served by cable TV network.

3. For Arab and emerging countries, Indicators used in the table are mainly according to ITU available data.

Table(8): Comparing Previous Empirical Broadband Studies In USA And OECD Countries:

Author	Research Topic	Methodology	Used indicators
Bauer, J.M., Gai, P., Kim, J., Muth, T.A., Wildman, S.S., 2003	Broadband uptake in OECD countries	Multivariate OLS for the year 2001 for 30 OECD countries	price of broadband, preparedness, competition and dummy variable for policy regimes. Income, population density, price of dial up
[1] Inmaculada Cava Ferreruela, Antonio Alaban-Munoz (2004),	Key constraints and drivers for broadband development: a cross national analysis.	Pooled OLS for 30 OECD countries for the years 2000-2002	bandwidth per $, lagged variable of DSL enabled Local loop, Unbundled local loop/100 access lines, monthly price of internet access and % of homes served by cable TV network, school enrollment, Internet host, Internet users.
Martha Garcia-Murillo and David Gabel (2003)	International Broadband Deployment, the demand for broadband	Logit regression and standard regression	% of Internet users, population density, GDP per capita, illiteracy rate, Residential monthly telephone subscribers, % of population with broadband, % of hosts in the country, % of PCs in the country, competition and ownership variables.

Source: author's research

Table(9): Results Review of Empirical Broadband Studies in USA and OECD Countries:

Paper reviewed	Results

Paper reviewed	Results
Bauer &al 2003. Investigated broadband diffusion in the OECD countries	The authors concluded that population density and preparedness (where the latter means the attitudes of the population toward is information technology) are statistically significant.
Ferreruela and Alabau-Munoz break down of the factors forming the supply, demand and penetration of broadband. Groups of variables were formed as they were classified as supply side and demand side and broadband penetration.	The paper concluded that the percentage of dial up Internet subscribers is the most influential factor for DSL adoption followed by the one year lagged availability of DSL infrastructure.
Distaso & al addressed the effects of *inter platform* competition, i.e. competition between alternative platforms such as cable access, fiber optics, high speed Internet access, and *intra platform* competition, which is competition between different providers of the Digital Subscriber Line(DSL) segment of the market.	competition between broadband providers with different platforms increases broadband penetration rate. However, competition among the providers of the same platform like DSL does not play a significant role in increasing broadband penetration.
Scott Wallsten (2005) "Broadband penetration, an empirical analysis of state & federal policies"	3. population density is positively correlated with broadband penetration and connection speed. 2. regulations that promote mandatory unbundling slow down the penetration growth of broadband. 3. mandatory on site collocation is correlated with faster penetration growth of broadband.
Scott Wallsten (2006) "Broadband and Unbundling Regulations in OECD Countries control for the different types of unbundling regulations implemented in the OECD countries	very extensive unbundling mandates and some types of price regulation can reduce broadband investment incentives. According to the findings of this paper there is no government policy that has a strong and clear positive impact on broadband penetration.
A.Goolsbee (2002)"Subsidies, the value of broadband and the importance of fixed costs",	1. markets in which broadband service is available, subsidizing the demand will increase consumer well being by less than equivalent policies that subsidize supply e.g. subsidizing investment in underserved markets.

Source: author's research