COST AND DEMAND DRIVEN PRICING MODEL FOR INTERNET SERVICES AND APPLICATION ON TURKEY'S CASE

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF INFORMATICS
OF
THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

MÜNİR MURAT ALSAN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN
THE DEPARTMENT OF INFORMATION SYSTEMS

DECEMBER 2006

Approval of the Graduate School of Informatics

____

Assoc. Prof. Dr. Nazife Baykal

Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

____

Assoc. Prof. Dr. Yasemin Yardımcı

Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

________________________	________________________
Assist. Prof. Dr. Uğur Soytaş	Dr. Altan Koçyiğit
Co-Supervisor	Supervisor

Examining Committee Members

Prof. Dr. Semih Bilgen	(METU, EEE)	____________________
Dr. Altan Koçyiğit	(METU, II)	____________________
Dr. Sevgi Özkan	(METU, II)	____________________
Assist. Prof. Dr. Uğur Soytaş	(METU, BA)	____________________
Dr. Cebrail Taşkın	(Türk Telekom)	____________________

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Münir Murat Alsan

Signature: _________________

ABSTRACT

COST AND DEMAND DRIVEN
PRICING MODEL FOR INTERNET SERVICES AND
APPLICATION ON TURKEY'S CASE

Alsan, Münir Murat
MS. Department of Information Systems
Supervisor: Dr. Altan Koçyiğit
Co-Supervisor: Assist. Prof. Dr. Uğur Soytaş

December 2006, 110 pages

This thesis proposes a pricing model for Internet access services. Firstly, demand, pricing and costing practices in communications sector are briefly explored. Then a pricing model for the ADSL Internet access service by Türk Telekom is described. The model uses the demand and cost information of a specific service and price is assumed as the key input. The model tries to find the optimum level of prices that maximize the profits under certain constraints regarding the network and customer concerns. The model and its output are discussed in comparison with the international cases and the scope of the further study is addressed in line with the developments occurring in the broadband access market.

Keywords: Telecommunications, Cost, Demand, Pricing, ADSL

ÖZ

INTERNET HİZMETLERİ İÇİN
MALİYET VE TALEP TABANLI FİYATLANDIRMA MODELİ
VE TÜRKİYE UYGULAMASI

Alsan, Münir Murat
Y.Lisans, Bilişim Sistemleri Bölümü
Tez Yöneticisi: Dr. Altan Koçyiğit
Ortak Tez Yöneticisi: Y. Doç. Dr. Uğur Soytaş

Aralık 2006, 110 sayfa

Bu tezde İnternet erişim hizmetleri için fiyatlandırma modeli önerilmektedir. Talep, fiyatlandırma ve maliyetleme yöntemlerine ilişkin kısaca bilgi verildikten sonra Türk Telekom'un ADSL İnternet erişim hizmeti için bir fiyatlandırma modeli anlatılmaktadır. Önerilen modelde belirli bir hizmete ait talep ve maliyet bilgileri kullanılmakta ve modelin temel girdisini fiyat oluşturmaktadır. Elde edilecek kârı en çok yükselten fiyat seviyesi, şebeke ve talebe ilişkin kısıtlar da dikkate alınarak belirlenmektedir. Önerilen model sonuçları ile birlikte uluslararası düzlemde tartışılmakta ve ileriki çalışmaların kapsamına ilişkin geniş bant erişim piyasasındaki gelişmeler de dikkate alınarak öneride bulunulmaktadır.

Anahtar Kelimeler: Telekomünikasyon, Maliyet, Talep, Fiyatlandırma, ADSL

To My Wife

ACKNOWLEDGEMENTS

I’d like to express my sincere gratitude to Dr. Altan Koçyiğit for his guidance, patience and support throughout the thesis. I’d also like to thank to Assist. Prof. Dr. Uğur Soytaş and Dr. Cebrail Taşkın for their very helpful comments and to my colleagues at Türk Telekom, especially to Mr. Nedim Eren, who provided the necessary information and insight during the preparation of this work.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AAL5: ATM Adaptation Layer 5

ARPU: Average Revenue Per User

ATM: Asynchronous Transfer Mode

BRAS: Broadband Remote Access Server

CBR: Constant Bit Rate

CT: Communications Tax

DiffServ: Differentiated Services

DSL: Digital Subscriber Line

DSLAM: Digital Subscriber Line Access Multiplexer

ERG: European Regulators Group

ERP: Enterprise Resource Planning

EU: European Union

FDC: Fully Distributed Cost

GSM: Global System for Mobile Communications

IN: Intelligent Network

IntServ: Integrated Services

IP: Internet Protocol

ISP: Internet Service Provider

L2TP: Layer 2 Tunneling Protocol

LLU: Local Loop Unbundling

LRIC: Long Run Incremental Cost

MC: Marginal Cost

MDF: Main Distribution Frame

MPLS: Multi Protocol Label Switching

NRA: National Regulatory Authority

OECD: Organization for Economic Cooperation and Development

PC: Personal Computer

POTS: Plain Old Telephone Service

PPP: Point-to-Point Protocol, *also* Purchasing Power Parity

PPPoA: PPP over ATM

PPPoE: PPP over Ethernet

PSTN: Public Switched Telephone Network

PVC: Permanent Virtual Circuit

QoS: Quality of Service

RSVP: Resource Reservation Protocol

SAC: Stand Alone Cost

SCT: Special Communications Tax

SDH: Synchronous Digital Hierarchy

SMP: Significant Market Power

TL: Turkish Lira (or YTL. 1 YTL = 1 TL)

USD: US Dollar

VAT: Value Added Tax

VBR: Variable Bit Rate

VoIP: Voice over Internet Protocol

WACC: Weighted Average Cost of Capital

xDSL: Generic term referring all DSL technologies

CHAPTER 1

INTRODUCTION

Advances in communication technologies brought a wealth of developments in applications and resulted in the expansion of the Internet. Although the roots of the Internet lie in the Military and Academic Institutions (Cerf, 2004), commercial and business world were not slow to respond to the great potential of the Internet. As in many industries, cost of service provisioning is decreasing in Internet, but the pace is much quicker (Minoli, 2003). The main components of networks are the equipments and underlying technologies which, unlike the human component, provide greater impact for improvement. The power of a processor as described by Moore's Law doubles every year and transmission rate of networks (especially over optical fibers) is increasing (Coffman & Odlyzko, 2002).

Although these advancements are certainly desirable, the economic realities do not go hand in hand with the scientific and technological developments. With markets fully becoming competitive and firms having very low real set up and other costs, which promote the entrance, there is a huge consumer surplus so that the consumers buy at a price below the maximum they are willing to pay. This means a decrease in producer surplus, where producers are selling at a price just above the minimum they are willing to accept. In a competitive market, the competition drives prices down to a level where "normal profits" are earned. In order to earn above normal profits, firms try to increase their market power by either focusing on cost reductions or intense marketing activities and service differentiation (Minoli, 2003). Currently, the incumbent operators are losing much of their revenue from traditional telephony services, which roughly constitute 80% of their total revenues (Minoli, 2003). In order to compensate the losses from traditional telephony services, these operators are investing heavily on IP (Internet Protocol) based networks. As a result, the return on these investments is now a major issue for most of the PSTN (Public Switched Telephone Network) operators.

Pricing is regarded as one of the variables of the marketing mix, which define the strategic elements of a specific market (Boone & Kurtz, 1995). Other variables of the marketing mix are product, distribution and promotion. Pricing is also regarded as one of the most difficult areas of marketing activities (Boone & Kurtz, 1995) and has a direct effect on firm's financial performance. Marn, Roegner and Zawada (2003) show that a typical S&P (Standard & Poor's) 1500 company would increase its operating profits about 8% with a price increase of 1%, whereas increase in sales volume by 1% would result in 2% or 3% increase in operating profits. However, the extent of the influence of pricing is not restricted to only financial results especially in networks. Pricing can establish the following directly or indirectly in communication networks as well:

- Control and shape user behavior
- Form a demand which better fits the service's capabilities
- Implement QoS (Quality of Service)
- Plan the development of network.

(Walrand & Varaiya, 2000; Odylzko, 1998; Li, Iraqi & Boutaba, 2004; Falkner, Devetsikiotis & Lambaradis, 2000)

The cost of pricing as a management tool can be very low as very small extra effort is needed on the current systems if a simple tariff structure is applied. Whereas the other components of marketing mix (distribution, product, promotion) result in greater costs to make changes and improvements, pricing can implement changes by the current billing systems with little or no additional costs (Falkner et. al., 2000).

The problem this thesis tries to address is to develop a pricing model for a broadband Internet service by finding a tariff structure, which maximizes the profit of a firm, given certain restrictions regarding the demand and costs. The model uses a generic demand model, which transforms each price level into the quantity demanded, which in turn determines an associated cost figure through a cost model. With key inputs on hand, namely the price, quantity and cost, the model tries to maximize the profit.

The thesis is based on the case of ADSL (Asymmetric Digital Subscriber Line) service offered by Türk Telekomünikasyon A.Ş.[1], which is the incumbent operator of Turkey. Although tariff and consumer data have not been verified by Türk Telekom for official use, it is still invaluable and enlightening to have first-hand sales and cost figures for an incumbent operator, which is growing its customer base in a broadband service.

Broadband access is affecting all operators and the technological changes such fiber to the home and optical access networks such Ethernet Passive Optical Networks (EPON)[2] represent both opportunities and challenges for incumbent operators operating the copper access network. Similar concerns apply for Türk Telekom, who has been offering broadband access services over Ethernet and updating its infrastructure to meet the needs of the customers (Section 3.3).

In addition, the thesis tries to fill the gap between the academic work on network pricing and the actual use on businesses through a business model, which can be more widely used throughout industries as implied by Fader and Hardie (2005). Moreover, the subject is of great importance for the governments of developing countries in terms of closing digital divide and being a part of the information society (European Commission, 2005).

---

[1] Türk Telekom is used throughout the thesis standing for Türk Telekomünikasyon A.Ş.
[2] Retrieved from http://www.infocellar.com/networks/new-tech/EPON/epon2.pdf on 09.12.2006

This thesis takes the perspective of a single firm, which faces very little competition from a fringe of small firms. For the sake of simplicity, it is assumed as a monopoly throughout the thesis. The firm tries to find a price level that increases profits for the short run. The model takes into account possible regulatory issues, cost considerations, demand information and international benchmarks. On the other hand, competitive, game theoretic issues are not handled by the model as competition and game theoretic analysis of strategic interaction are not relevant for a monopoly. The monopolist's market power (ability to make prices) is limited only by the demand function. Additionally, a firm with monopoly power can maximize profits by transferring a portion of consumer surplus to itself via price discrimination. One way of attaining price discrimination is to apply "two part tariff pricing" (Section 2.4).

Since the problem is short run maximization, macroeconomic variables (except a discount rate to value investments) are also excluded from the analysis with the assumption that most macro variables are constant in the short run.

The rest of the thesis is organized as follows:

- Chapter 2 focuses on foundations of the proposed model. Possible demand estimation tools and a summary of optimization methods are provided. This chapter also describes the pricing methodologies in line with networks and includes a brief analysis of the costing practices in the communications sector.
- Chapter 3 includes information about the ADSL service and Türk Telekom's ADSL offer.
- Chapter 4 presents the proposed model, describes the formation of the pricing model by using the results presented in literature and shows the results.
- Chapter 5 comments on the proposed model and addresses the possible issues to be addressed in future works on the subject.
- References section lists the sources referenced throughout the text.

- Appendices includes OECD broadband statistics, statistical analysis of the demand model, monthly usage figures of Türk Telekom subscribers, Türk Telekom’s and other international operators’ tariffs.

CHAPTER 2

MARKETS, PRICING AND COSTING

Purpose of this chapter is to provide the background in the economics of providing a broadband service. The first section is about the demand (consumer) side and the second section is about the details of supply and other economics concepts. The third section gives brief information on optimization methods. The fourth and the fifth sections deal with pricing and cost concepts respectively. The chapter ends with a discussion of other important factors especially regulatory and competitive aspects that affect pricing.

2.1 Demand

Demand and supply are the two economic forces defining a market. They are the two forces through which the pricing mechanism works to reach market equilibrium. Demand is the amount of commodity that the consumers are willing to buy at specific prices in a time period, all factors other than price are held constant. Supply is the amount of commodity that the producers or service providers are willing to sell at specific prices in a time period, all factors other than price are held constant (Keat & Young, 1996).

The demand for Internet services is a derived demand (Walrand & Varaiya, 2000). This means that Internet services are not end commodities that satisfy consumers' needs, but a means to the services, which satisfy the need. For example, the content published on the Internet is the commodity that satisfies a consumer's need and an access service like dial up may serve as a tool to reach that commodity. Each consumer has a utility function regarding a product or a service. This utility function forms the foundation of demand functions.

2.1.1 Utility Function

Each consumer has a specific taste that affects his/her appreciation of goods or services. Each consumer's utility for a commodity x may be defined as u(x) and price of good as p(x), then the user solves a maximization problem:

$$Max\ [u(x) - p(x)] \qquad (2.1)$$

Generally, consumers have to choose among many services (n services) in order to maximize their utilities. So Equation 2.1 can be rewritten as:

$$Max \sum_{i=1}^{n} [u(x_i)-p(x_i)] \qquad (2.2)$$

The most important thing to note for understanding the demand for goods is the principle of diminishing marginal returns. This theory basically states that for a good or service, after a certain level of amount the utility provided with each incremental amount decreases. That is $\partial u(x)/\partial x_i$ is a decreasing function (Keat & Young, 1996). The result of the principle of diminishing marginal returns is the demand curve of service *x* in the Figure 1.

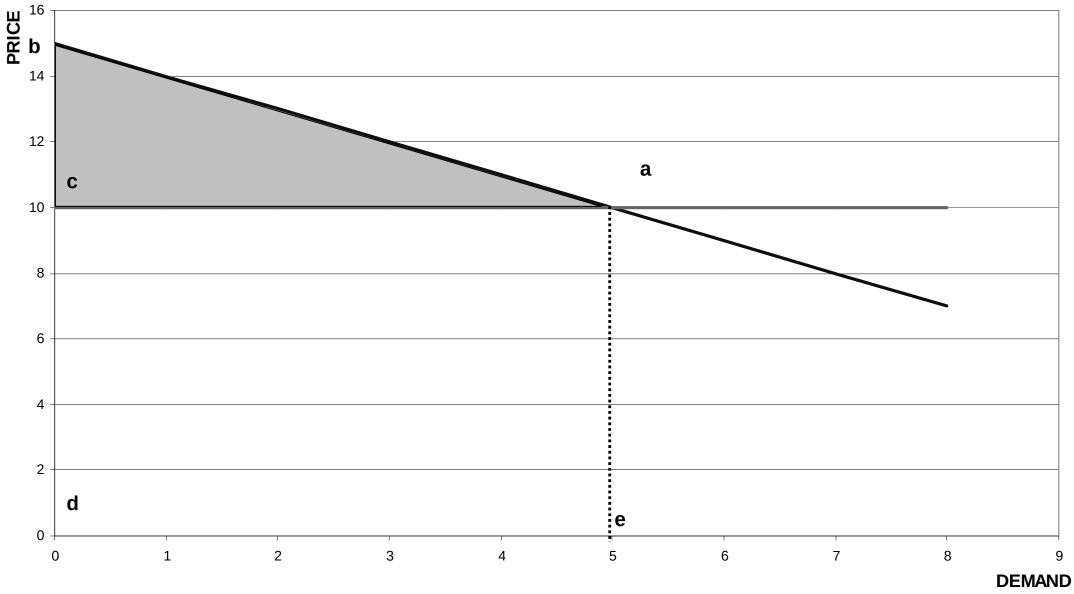

Figure 1: Demand Curve.

In Figure 1, the y axis represents the price, whereas the x axis represents the quantity demanded at each price level. Considering the (x, y) = (5, 10), the upper triangle *abc* represents the consumer surplus and the rectangle *acde* represents the producer surplus plus the costs. By reexamining the utility function, it can be seen that the total utility is represented by the area *bdea* and p(x) is represented by the area *acde*. So each user is in fact trying to maximize its triangle *abc*, consumer surplus, shown as the shaded area in Figure 1.

2.1.2 Elasticity of Demand

In microeconomic models firms have two strategic variables: amount produced and price. Perfectly competitive firms maximize profit by choosing the appropriate quantity. Firms with market power choose both the output and the price levels that maximize profits. One of the most critical components of demand that is related with marketing activities is the price elasticity. Price elasticity is the percentage change in demand in response to a percentage change in price and is represented as $\partial q(p) / \partial p$, where *q(p)* stands for the natural logarithm of demand and *p* stands for the natural logarithm of price (Keat & Young, 1996).

The elasticity measure is always negative as demand is downward sloping. If the absolute value of elasticity is:

- >1; demand is elastic, i.e. the demand increases more than the change in price (in terms of percentages)
- <1; demand is inelastic, i.e. the demand increases less than the change in price (in terms of percentages)

Price elasticity is important in the sense that pricing decisions must always be with regards to elasticity information (Montgomery, 1988). For a good or a service that has elastic demand, it may be advantageous to offer promotions or price decreases. On the other hand, the same decision cannot hold true for inelastic demand, where a price reduction will most possibly lead to decreases in revenue.

Other than a product's own price elasticity, various types of elasticities exist. Most common of these are the *cross-elasticity*, which shows the percentage change in demand of a commodity in response to a percentage change in price of another commodity and the *income elasticity*, which represents the percentage change in demand of a commodity in response to a percentage change of income.

Marshall (1982) proposed that the derived demand curve would be more inelastic when:

1. The related component is more crucial
2. The demand for end product is more inelastic
3. The expenditure for the component has a smaller amount
4. The supply factor of cooperating factors is more inelastic

2.1.3 Forecasting Demand

According to Montgomery (1988) forecasting methods of demand can be of 3 types:

1. Judgmental
2. Market and Survey Analysis
3. Formal Modeling

Judgmental methods rely on the opinion of experts, executives or sales force. These are simplest methods and require less time than the remaining methods (Montgomery, 1988) but are qualitative in nature (Boone & Kurtz, 1995).

Market and Survey analyses are invaluable tools to reveal the consumer's opinions about the products or services. They are usually slow to implement and very costly. Yet results can be quite accurate if care is given to the techniques used in the surveys. On the other hand, respondents in the surveys do not necessarily turn their intentions into buying patterns (Boone & Kurtz, 1995). In that sense, market tests are used in order to evaluate consumers' responses to marketing mix variables under actual market conditions albeit in a smaller than real market.

Formal models are based on historical data, statistics and econometrics. They can be time series models or causal models (Montgomery, 1988):

1. Time Series Models
    a. Simple moving averages
    b. Weighted moving averages
    c. Exponential smoothing
    d. Adaptive filtering
    e. Box-Jenkins
    f. Decomposition methods
2. Causal Methods: Regression Models

Time series models relate the dependent variable to functions of time and are especially useful when parameters describing the time series remain constant over time (Bowerman, O'Connell & Koehler, 2005). Trend models are generally used for describing time series. Trends can be one of the following:

1. No change
2. Straight line growth or decline
3. Growth or decline at an increasing rate
4. Growth or decline at a decreasing rate

Life cycle approach is based on the time series models and assumes product's or service's development over its lifetime (Monroe, 1990). From a life cycle perspective, the forecasting methods can be classified as:

1. Introduction: Qualitative (Market research)
2. Growth: Time series (Exponential smoothing)
3. Maturity: Time series (ARIMA: Autoregressive integrated moving average) and econometric modeling
4. Fall – off: Time series
5. Abandonment: Abandonment decision

(Levenbach & Cleary, 2005; Monroe, 1990)

It can be seen from Figure 2 that time series models are preferred primarily in the growth and decline phases of the product or service. This is due to the fact that causal methods do not perform well when relation among time ordered error terms, autocorrelation, exists (Levenbach & Cleary, 2005). Causal methods tend to exaggerate the effect of independent variables by hindering the effect of time series information, and transferring the weight of time series variables to the regression variables.

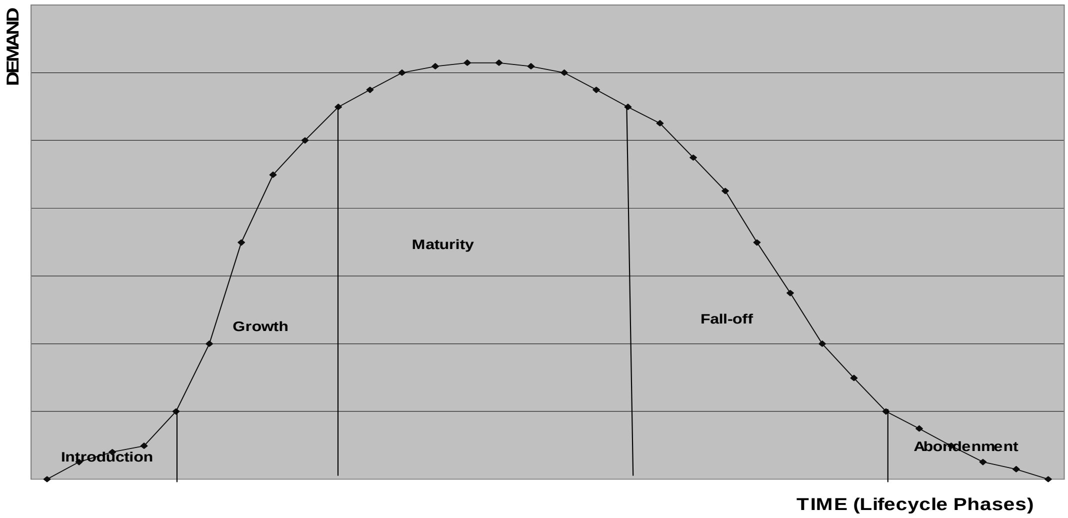

Figure 2: Life Cycle of a Product or Service[3]

Growth models are especially useful for analysis of the new products or services. During growth phase of a product or service, the trend often observed is generally an S-shaped curve (Figure 3).

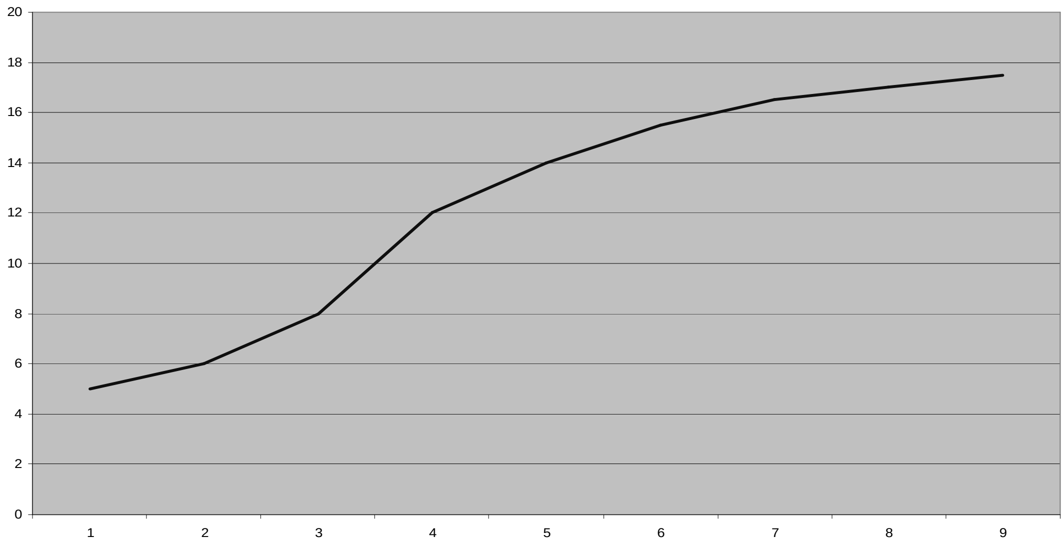

Figure 3: A Typical S Curve.

[3] Levenbach & Cleary (2005)

One of the S-shaped curves is called Gompertz Curve (Winston, 2000);

$$Y = Le^{-be^{-kt}} \tag{2.3}$$

Where Y is the dependent variable, t is the independent variable, L is the upper limit for Y, k is the minus slope of regression and b is the $e^{\text{int}\,ercept}$. From Equation 2.3 $\ln(\ln(\frac{L}{Y})) = \ln(b) - kt$ is obtained. If Gompertz curve is observed, there is a linear relationship between $\ln(\ln(\frac{L}{Y}))$ and t (Winston, 2000).

Regression models express demand as a function of a certain number of factors. They are a form of probabilistic models where the variable of interest is a factor of both deterministic component and random error (McClave & Benson, 1991). In its simplest form, regression equation can be represented as a linear model in the following form:

$$Y = \beta_0 + \beta_1 X + \varepsilon \tag{2.4}$$

Where Y is the dependent variable, β_0 is the constant (intercept), β_1 is the coefficient (slope) of the independent variable X and ε is the random error term.

In order for the linear regression model to yield robust results, the model shall satisfy four assumptions. These are:

1. Constant variance assumption: The variances of the residuals for every set of values for the independent variable are equal. Violation of this assumption is called heteroscedasticity.
2. Normality assumption: The conditional probability distributions are normal at each value of the dependent variable.
3. Independence assumption: The expected correlation between residuals, for any two cases, is zero.

4. Linearity: The means of conditional probability distributions at each level of independent variable should fall on a straight line.

(Bowerman et. al., 2005; Miles & Shevlin, 2001).

Unless these assumptions are severely violated, the estimated regression model can be used for inference like estimation and hypothesis testing.

2.2 Supply, Economies of Scale and Economies of Scope

Whereas the users try to maximize their benefits, the firms try to maximize their profits. Given the technology (that is the production function and therefore its mirror image the cost functions), the firm wants to maximize its profit by choosing an output-price level. In Figure 1, the firm's revenue is represented as *acde* (quantity demanded x price per unit). If the firm is revenue maximizer, it tries to maximize the rectangular area *acde* in accordance with its supply function. Here the firm may be:

1. A price taker in a competitive market, where it is obliged to take the price enforced by the market
2. Free to define the price according to the cost and demand curves when it is a monopoly
3. Applying the enforced price by an authority, which is usually the government

A market supply curve might be described as the sum of all individual suppliers' curves. These curves are the part of marginal cost curves of firms that are above their average variable cost curves (Figure 4).

Marginal cost incurs by producing an extra amount of output. The shape of marginal cost curve represents the fact that in the short run at least one factor of production or service is fixed (generally capital is assumed as fixed). As increases in output occur, other factors of production are utilized along with the fixed factor. Hence, after a certain level of output an upward sloping marginal cost curve is observed.

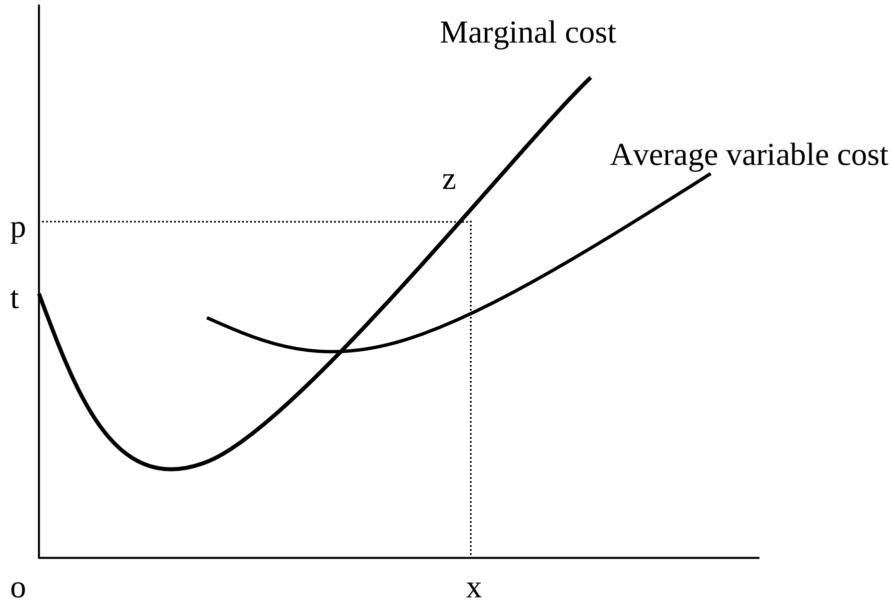

Figure 4: Marginal Cost and Average Variable Cost Curves Intersecting.

Average variable cost is computed as the total variable cost divided by the total output level. The part of marginal cost curve above the average variable cost curve forms the firm's supply curve. In the short run, the firm produces above average variable cost to earn operating profits. These operating profits are then used to cover at least a portion of the fixed cost. So it is only possible to supply products or services at prices above the intersection point of the two curves (Figure 4). The sum of all individual firms' demand curves forms the market supply curve. For each price level (y axis) the producer surplus corresponds to the area above the supply curve below price, which is the minimum revenue to produce or serve the commodity.

In Figure 5, a perfectly competitive market is represented. In a competitive market, the equilibrium price is the price that maximizes social welfare, which is the sum of producer and consumer surpluses.

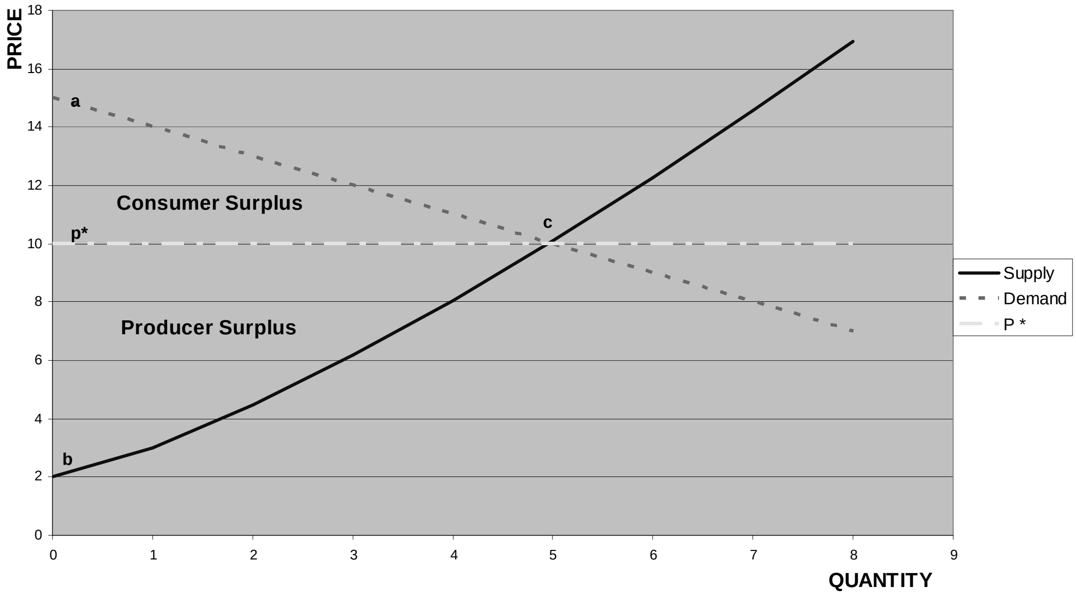

Figure 5: Consumer Surplus and Producer Surplus.

A monopolist does not have a supply curve. It chooses an optimum point on the demand curve it faces alone. The monopolist first selects the optimum output level by setting marginal cost equal to marginal revenue, then determines the optimum price that corresponds to that output level on the demand curve. A monopolist's price is usually higher than a price level that is maximizing the social surplus *"bac"*, which is the sum of the producer surplus *"bp*c"* and the consumer surplus *"cp*a"* as represented in Figure 5. A discussion of other market types (competitive, oligopoly, and others) and their characteristics can be found in Carlton and Perloff (2000).

Two important concepts for producers or service providers are *economies of scale* and *economies of scope*. Economies of scale occur when a firm produces at a level of output that brings accompanying decreases in unit costs. This is generally referred to as increasing returns to scale. In telecommunications sector, economies of scale are the result of high level of fixed costs, which are not related to the output level (Intven, 2000). Economies of scope, on the other hand, are not a function of quantity but a function of variety of outputs the firm is providing. Common resources may facilitate the provision of multiple services as compared to separate provision (Intven, 2000).

2.3 Optimization Methods

Operations research or management science is described as a scientific approach to making decisions under certain conditions, which requires the allocation of scarce resources (Winston, 2004). It tries to find a solution for the design or operation of a system using mathematical models. Optimization models are generally in the format shown in Figure 6.

Objective Function

Maximize $Z = c_1x_1 + c_2x_2$

Subject to

Constraints

$a_{11}x_1 + a_{12}x_2 \leq b_1$

$a_{21}x_1 + a_{22}x_2 \leq b_2$

……

Figure 6: General Form of an Optimization Model

Objective function contains a statement either to be maximized or minimized. An optimization model might have more than one objective function. Objective function contains *decision variables*, whose values can be altered to find a solution. *Constraints* are added to the optimization models to represent the nature of scarce resources. Solutions of a model satisfying the constraints form a feasible region and on this feasible region optimal solution(s) gives the best solution to the problem.

Optimization models can be linear or nonlinear. If a model contains variables multiplied by constants and added together, this model is called a linear model. However, there are many real world cases that cannot be represented by linear models. In linear models, feasible region is convex meaning that the line connecting any two feasible points is also feasible. However, for nonlinear problems feasible region need not be a convex set. Also a local maximum or minimum point may not be the optimum solution to a nonlinear problem, which is the case for linear problems (Winston, 2004). Calculus based methods using hill climbing routines might come up with solutions, which are local extremums. Although evolutionary (or genetic) algorithms overcome this drawback, they are usually time inefficient (Baker, 1998).

From a time point of view, problems can be either static or dynamic. If the problem does not require multiple decision makings over time, it is a static model. Otherwise, the problem is called a dynamic model, where sequential decisions are made over periods (Winston, 2004).

2.4 Pricing In Networks

Pricing and the formation of tariffs require the knowledge of multiple fields; including cost accounting, networking, economics and marketing. Before reviewing the pricing techniques used for network services, its roots in economics shall be defined, as the user behavior is a major determinant of the determination of prices.

Price is the exchange value of a good or service (Boone & Kurtz, 1995). Tariff, on the other hand, means the overall structure of prices (Courcoubetis & Weber, 2003). For network services general form of tariff is a two-part tariff, which includes a fixed and a usage price and is depicted as in Equation 2.5.

$$Y = F + U * x \qquad (2.5)$$

Equation 2.5 is a generally applied type of telephony tariff, where F is the call setup price irrespective of the duration of call, U is the price per second and x is the duration of call in seconds.

The NUT trilemma presented by (Stiller, Reichl & Leinen, 2001) classify the pricing methods according to *network*, *user* and *technology* (NUT) characteristics. All of these characteristics have time dimension. Whereas user characteristics represent the longer periods as defined in contracts, technology characteristics represent the shortest time frames. The tariffs should be simple because it makes them easily understandable by users, who do not favor complex tariffs, even the more technically oriented ones. The trade off between simplicity of tariffs and price effectiveness and cost provisioning is a crucial problem for service providers (Stiller et. al., 2001).

Dippon (2001) adds other dimensions to the network, user and technology: regulatory, competitive and financial competency. Falkner, Devetsikiotis and Lambadaris (2000) evaluate different pricing schemas according to:

1. Compliance with existing technologies
2. Measurement requirements for billing and accounting
3. Support for traffic control or traffic management
4. Provision of individual QoS guarantees
5. Degree of network efficiency
6. Degree of economic efficiency
7. Impact on social fairness
8. Pricing time frame
9. Effective bandwidth pricing
10. Proportional fairness pricing

The subsections below represent some of the important concepts of pricing and major costing concepts used in communication networks.

2.4.1 Flat Rate Pricing, Usage Based Pricing and Paris Metro Pricing

When a negatively sloped user demand model is observed, one may come up with the idea that users value services differently and each price amount coincides with a different amount of service. The area formed with this line and the two axes form an area that a service provider tries to fill in. If a service provider uses a single charge (flat rate) for the service irrespective of usage, it will only gain a limited area (in other terms not maximize its revenues). As shown in Shin and Weiss (2000), flat rate is not a valuable charging method for both the user and the provider due to the following reasons:

- Subsidization of heavy-usage subscribers by low-usage ones
- Inability to segment the market
- Inefficient use of resources

On the other hand, flat rate is a simple and easy to deploy pricing scheme. It requires no extra mechanisms to the current network and billing infrastructure. Moreover, its simplicity is very well received by the users and socially flat rate pricing is a fair option (Falkner et. al., 2000).

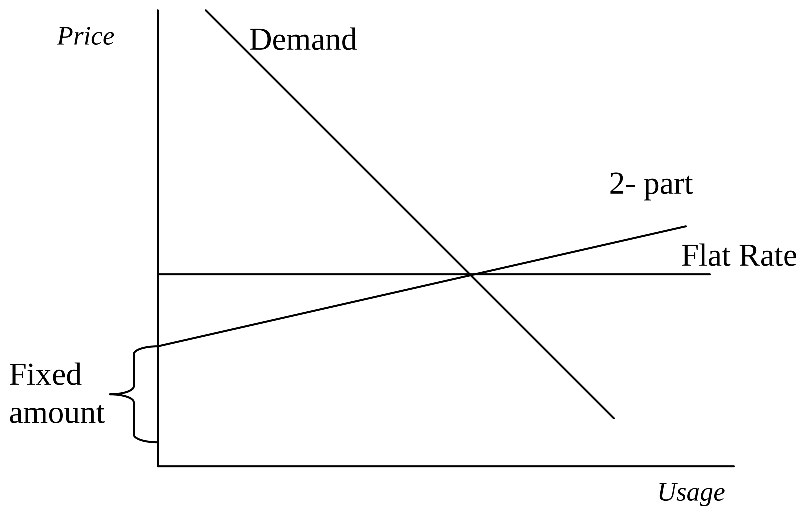

Figure 7: Two Part Tariff vs. Flat Rate Tariff.

A two (or more) part tariff's advantage is that provider has the ability to segment the market for each price associated with a usage amount (Figure 7). Additionally, it reflects the underlying variable costs of a service rather than putting these costs under a fixed charge (Falkner et. al., 2000) and in the end satisfy the deterministic principle in cost accounting to a greater extent. Subsidization of heavy usage consumers by low usage consumers is avoided in usage based pricing (Walrand & Varaiya, 2000), which greatly reduces the economic efficiency of flat rate pricing.

However, it is clear that pricing structure changes with the nature of the service. A service like high speed ATM backbone service hardly needs two-part tariff structure as its granularity is very hard to identify due to the extreme size of throughput. There are also oppositions to two-part and other complex pricing types (Odlyzko, 2001a; Odlyzko, 2001b) as historical trends show that simpler pricing mechanisms dominate most of telecommunication sector. A strong argument is that although there is finite capacity on Internet, users also have finite resources (time, money) for consuming the capacity. A striking example is the use of telephony services in USA, which has settled to 40 minutes per day level for decades, and flat rate pricing is applied (Odlyzko, 2000).

Odlyzko (1997) offers a pricing mechanism relying solely on the economic principles of price discrimination (Phlips, 1983) without changing the basic principles of flat rate pricing. *Paris-Metro pricing* divides the network into logical sub networks that are identical in nature. The sub networks are best effort IP networks with different prices. A user, who is assumed to be price sensitive, chooses one of the sub networks according to the budget and expected level congestion. For a long time period there is going to be less congestion in the highly priced networks. Paris-Metro pricing is an improvement over flat rate pricing especially in economic utilization, but the quality problems may arise when network is congested (Falkner et. al., 2000).

2.4.2 Marginal Cost Pricing

Marginal cost pricing refers to setting the prices equal to marginal costs. Whereas consumers try to maximize their utility, producers try to maximize their profits. A social planner as the state tries to maximize the social surplus, which can be defined as the sum of consumer and producer surplus, or in other words the total utility of the consumed services minus the cost of service provisioning (see Figure 5). By choosing a price *p*, where supplier's marginal cost "*c(x)*" and consumer's marginal utility "*u(x)*" equals, social surplus can be maximized (Courcoubetis & Weber, 2003):

$$\frac{\partial u(x)}{\partial x} = \frac{\partial c(x)}{\partial x} = p \tag{2.6}$$

Above problem is generally defined as the social planner problem, as state or regulatory authority tries to find a price level p maximizing the social welfare, or making both the producers and consumers satisfied.

Marginal costing is actually a type of usage based pricing. Although marginal cost concept is useful for the economic reasons behind the pricing, Courcoubetis and Weber (2003) list the following disadvantages:

1. Marginal costs are difficult to compute.
2. Unless carefully defined, the marginal cost may be equal to either zero or to infinity.
3. Time frame of marginal cost definition shall be carefully determined.
4. Marginal cost pricing may not be applicable as demand and resulting dimensioning of the network cannot be exactly forecasted.

A detailed review of cost concepts and cost methodologies is provided in section 2.5.

2.4.3 Ramsey Prices

Marginal cost pricing allows the producer to cover its marginal (short term) costs. Yet in some industries like telecommunications, the initial cost of investment forms the main part of costs. As a result marginal cost pricing may fail to achieve maximizing the social surplus when firms face losses (Intven, 2000).

Ramsey pricing (OECD, 2004; Courcoubetis & Weber, 2003) uses a weighted objective function and social welfare maximization problem is solved under the condition that the firm achieves non-negative profits. For independent services, Ramsey prices are greater than marginal cost prices. Ramsey prices deviate proportionally to the inverses of demand elasticities. If services are not independent (either substitutes or complements) then Ramsey prices may be below marginal cost (Courcoubetis & Weber, 2003; Falkner et. al., 2000). The general principle of Ramsey Pricing is that the products having least price sensitivity must have the highest prices relative to their costs (Intven, 2000).

2.4.4 Resource Pricing and Smart Market Pricing

Internet is generally called as the network of networks. As its dimensions are extremely large, it includes many network components interoperating to provide the necessary communication. These network components, each as a resource, form the costs for the associated services, and these services provide the utilities for the users. When usage of a resource is scarce (due to the aggregate user behavior, supplier behavior, or some political reason) that resource is valued accordingly and its weight in the total cost of service increases. This revaluation, if reflected to the user, meets either with an approval or denial of the new valuation. Those users willing to accept the new value of the resource receive better service compared to the deniers. This difference in costs, the *shadow price*, is defined as the “marginal increment in expected cost of a resource resulting from a marginal increment in the scarceness of the resource” (Gibbens & Kelly, 2000).

When a user wants to maximize its utility, it may simply apply for a larger share of resources and pay for that share. This share consists of not only the cost for the user, but also cost for other users as their utilities diminish due to that user's utility self-maximizing behavior (Walrand & Varaiya, 2000). This notion is a critical part of differentiated pricing since it takes into account utilities and costs and this economic approach is necessary for profit maximization of the firm.

Smart market pricing takes into account the resource usage as social cost imposed on other users and the capacity expansion. Smart market pricing is established through an auction mechanism. In this sense, smart marketing pricing is value based; network usage information may not itself be a useful indicator of cost. The valuation of resources by the user is an indicator of economic efficiency in smart market pricing (Falkner et. al., 2000). Bids above the threshold value are allowed to be transmitted. The value of the threshold defines the marginal cost of congestion and the revenues equal to the optimal investment to expand the network. On the other hand, complexities of implementation exist due to noncompliance with existing technologies and poor people may not utilize the service at all, which may require governmental intervention (Falkner et. al., 2000).

2.5 Cost Methodologies

2.5.1 Basic Concepts

Knowledge of basic cost concepts is crucial for understanding the different types of cost methodologies. The costs incurred by a multiproduct firm with 5 different products are depicted in Figure 8, which shows that there are various types of costs associated with each type of product.

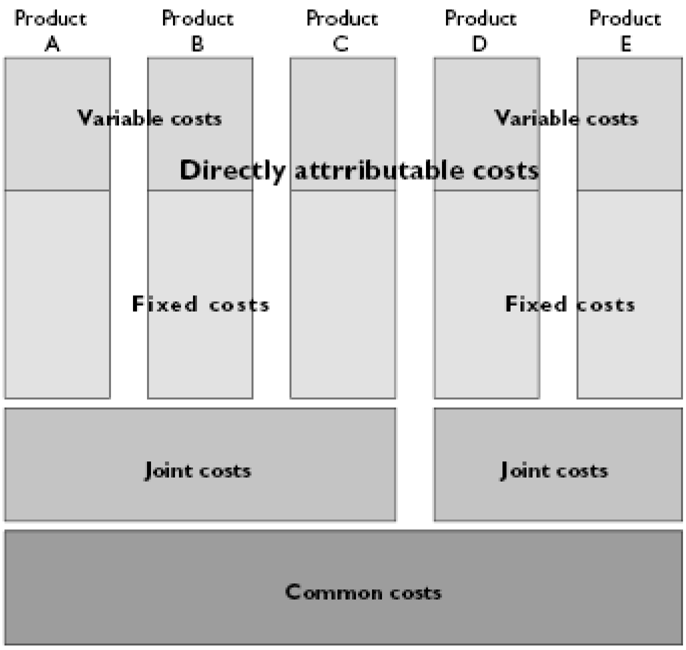

Figure 8: Costs for a Multiproduct Firm[4]

Common costs form the bottom line of the firm's costs. They are shared by all services or products of the firm, such as a license fee or overheads (Um et. al., 2004). *Joint costs* are very much like the common costs except that they are generated by a group of services. Common costs and joint costs cannot be directly attributed to the services: there can either be an indirect relationship or some sort of arbitrary attribution.

Directly attributable costs can be related to services without any sort of parameter or allocation key[5]. These costs completely derive from a specific service. *Fixed costs* do not deviate with the output (or services) of the firm (Um et. al., 2004). *Sunk cost* is a special type of fixed cost, which cannot be avoided even if the firm ceases production or service entirely. These costs are not taken into account in marginal cost analysis as they are unrelated to output (Intven, 2000). In the short run fixed

[4] Um, Gille, Simon & Rudelle (2004)
[5] An allocation key can be a parameter or characteristic of a service that is used to allocate fixed or joint costs to the services. Eg. Number of customers of each service can be used as allocation key to allocate overhead costs to each service.

costs are not assumed to be changing. *Variable costs*, on the other hand, change with the level of output. Examples of variable costs are direct material, direct labor, and some of the marketing costs.

2.5.2 Approaches to Cost Accounting

A successful cost process can only be established by the use of an adequate cost accounting system. There are various approaches to different aspects of cost accounting.

- **Bottom-up and Top-down Approach**

Two approaches, bottom-up and top-down, are both recommended by European Commission for cross validation purposes (Andersen, 2002). Bottom-up approach tries to establish a cost model through analyzing future demand, network design and costs. As its name implies, this approach starts from scratch and tries to establish a cost model. Bottom-up models can be established with lesser information than top-down, thus preferred by the regulators. Despite relying on the quality of its assumptions, bottom-up approach has the ability to eliminate the inefficiencies of operators (Andersen, 2002). Top-down approach regards the company accounts as its primary input and distributes these “book” values among the services.

- **Scorched Node and Scorched Earth**

Cost models can either be based on existing network topology (scorched node) and an ideally efficient one (scorched earth) (Andersen, 2002).

- **Historical Cost and Current Cost**

Historical costs include accounting and other historical data (Intven, 2000), which can be adjusted to take into account time value of money (Um et. al., 2004). In contrast, current costs are primarily used in bottom-up models in order to find the cost of building infrastructure at the time calculation (Um et. al., 2004; Andersen, 2002).

2.5.3 Cost Modeling Methods

Cost modeling methods generally used in communication sector are explained below (Andersen, 2002):

1. Fully Distributed Cost (FDC): FDC method tries to allocate all costs of a firm to the services it provides. The types of costs can be classified as:
    a. General and Administrative Costs (all services use)
    b. Common Costs (specific for certain services)
    c. Fixed costs of a service that is unresponsive to the service provisioning
    d. Variable costs changing with the level of output

    The last two cost types are directly related with the service, whereas the first two shall be allocated to the service under certain assumptions and calculations.

2. Stand Alone Cost (SAC): Stand alone costs take a single service and tries to find the costs as only this service is provided. So all costs not directly associated with the service (overheads and common costs) are fully allocated to this service. SAC gives the maximum cost that a service can have.

3. Marginal Cost (MC): Marginal cost tries to find out the cost or saving from a 1 unit of increase or decrease. It takes into account only the costs responsive to service provisioning, while excluding common costs and overhead.

4. Long Run Incremental Cost (LRIC): Long run incremental cost takes into account the costs directly related with the service, and excludes the common costs shared with other services. This method is very much like the MC, except the fact that LRIC is used to calculate the cost of increasing the

output. It is the cost attributed only to additional output (Figure 9) and is regarded as the base cost method to identify costs for a service.

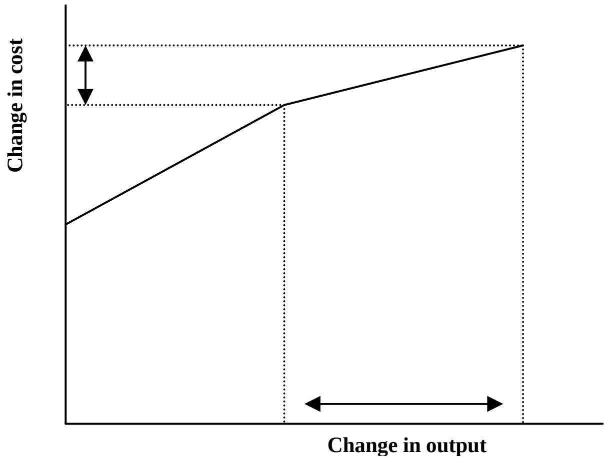

Figure 9: LRIC Methodology.

In communications sector, FDC and LRIC are the most widely used cost methodologies. Table 1 compares the advantages and disadvantages of FDC and LRIC.

Table 1: Advantages and Disadvantages of Costing Methodologies[6]

	FDC	LRIC and LRIC +
Pros	• Easier to develop • Relies on accounting data already available • Easy to audit	• Subsidy-free prices • Efficient and competitive prices
Cons	• Little or no incentive for efficiency • Generally not using causal relationships	• Hard to develop, need time and effort • Hard to understand

[6] Courcoubetis and Weber (2003)

A particular network service shall at least use one distinctive part of the network. As the number and type of networks used by the service increases, the identification of costs related with the associated networks hardens as:

- Each network is used by more than one service,
- The rate at which service uses the network is difficult to identify,
- The flow of data among different networks is subject to different contention ratios, which restrict the service’s use of that network.

The identification of costs is very much linked to the firm’s resources to get the necessary information. The better the company’s ability to differentiate among different cost items, the better it relates the items to the services on a deterministic principle. In this context, deployment of Enterprise Resource Planning (ERP) systems is certainly desirable but not always available. ERP systems try to integrate all data and process of a company into a single system, which helps the company to relate activities to the services at the time resources are consumed (Figure 10).

Resources → consumed by → **Activities** → trigger → **Cost items**

Figure 10: Basic Schema for Cost Allocation Process.

When all the components that a service uses are correctly identified and collected, the allocation of the costs for the service is established. This may be done by observations, measurements, evidence, or simply by an expert’s hypothesis. Measurements and evidences are clearly the preferable allocation methods, but others can be deployable if the firm lacks the capability to retrieve accurate resource consumption information.

2.6 *Other Concerns Regarding the Pricing*

2.6.1 Trends

Continuous observation of the trends is crucial at least for two aspects:

1. Observation of the trends gives important knowledge of which new technologies to invest, which ones to upgrade, which ones to leave.
2. Observation of trends is also important for providing possible revenue information. Due to decreases in investments and operating costs, newer technologies generally result in lower prices and revenues. By introducing new and alternative technologies, each operator shall be aware of the fact that cannibalizing can affect the expected gains from a new technology or application. For example, GSM, VoIP (Voice over IP) and possible alternatives providing voice services apart from PSTN have forced incumbent operators look for solutions to keep their customers (Minoli, 2003). In the end, Intelligent Networks (IN) and other technologies have been developed to provide value added services that are available through the traditional lines. Alternative services and other forms of value added services like *product or service bundling* can offset possible losses from migration to a substitute service (Minoli, 2003).

It is also critical to interpret figures that are available in various forms:

1. Penetration figures: These show the saturation level of the market. When interpreted with historical data, and in alliance with information that of the similar products; the size of the market can be estimated. It is useful to evaluate the development of these figures in countries, where the markets have reached their maturity stage.

2. Market size (revenues, number of players): ARPU (Average Revenue Per User) shows how much revenue is generated from a subscriber. Comparison

of this figure to that of the national and global markets shows the profitability and stage of the market. Low ARPU levels may imply that:

a. Prices are set too low
b. Costs are too high
c. Competition is high; so some firms will have to leave the market
d. There are strong alternatives to the product

3. Price developments in other countries: This is a critical subject to consider as most firms imitate the other firms' pricing techniques. Continuous follow up of markets is a valuable input for a firm to come up with solutions to pricing. Even regulatory authorities use benchmarking as the main tool for their activities: In Germany and Denmark, regulatory authorities relied on international benchmarking for determination of interconnection rates in the late 1990s and early 2000s (Vogelsang, 2002; ITU, 2003).

4. Network figures: One of the most important developments in recent years has been the increase in access speeds. This increase has been matched by the increase in backbone. Today international transmission costs are reduced to compatibly low levels. Although it is an important cost component, it is no more a significant burden for service providers. With access speeds and international transmission ever increasing, firms are facing with the problem of dimensioning their national networks. These are still important costs as the national transmission is still dominated by the incumbents in spite of the ongoing liberalization efforts. As addressed by Crowcroft, Hand, Mortier, Roscoe and Waterfield (2003), the relationship between the access network and backbone network is important in terms of service offering and investment decisions.

2.6.2 Competitive and Regulatory Aspects of Pricing

Competitive and legal aspects are far too complex in terms of defining their inputs and outputs and are beyond the scope of this work. On the other hand, it is important to be aware of regulations that govern a specific sector. This section briefly describes some of the recent issues about pricing and regulatory activities.

Telecommunications markets are generally regulated by national regulatory authorities. During 1990s, a transition from the old model of PTT (Postal Telegraph and Telephone) type telecommunications model, where an incumbent was both the server and the planner of the telecommunication sector in a country, into a regulatory-state model was established in Europe. This can be largely attributed to globalization and the convergence of the information and communication technologies due to the advances in the network applications (Humphreys & Simpson, 2005). In order to ensure the competition in markets, the national regulatory authorities (NRAs) imply regulations and policies in terms of pricing, so that a significant number of new operators are able to compete with the incumbents effectively. The regulations are generally effective on firms either having SMP (significant market power) or being a monopoly. Most important of these regulations are:

1. Price caps: Limits to the changes of prices of specific services (usually called baskets) imposed by the NRAs.
2. Preventing predatory pricing: Intention to eliminate rivals while incurring losses.
3. Controlling the price of inputs applied to the end user and the other firms (Preventing price squeezing): In order to increase the level of competition, a firm may be obliged to offer the product to other firms at a level far below than to its end-users.
4. Preventing cross-subsidization: Charging a service with lower prices by charging extreme prices for another service.

For broadband markets, in order to achieve the ladder of investment, regulatory bodies either make use of cost basis or retail minus approach for regulating the markets. Both approaches have their advantages and disadvantages. For example, Ofcom (2005) considers cost basis approach where the objective of regulation is to move the retail market structure towards effective competition. In that sense LLU (Local Loop Unbundling) and wholesale line rental services are appropriate for cost based approach. On the other hand according to Ofcom (2004) retail minus approach is suitable where wholesale or interconnection markets are yet not competitive and where a market is at a relatively early stage in its development and there is significant uncertainty about future market developments.

The use of these methods clearly affects the development of markets in the liberalizing economies. Although an approach may be far preferable over the other, it must nevertheless be carefully implemented. For new services, in order to achieve the developments in infrastructure, retail minus approach may be preferred to give the firms incentives to invest more in the infrastructures by additional profit margins let by higher prices (Ofcom, 2004).

CHAPTER 3

ADSL SERVICE

3.1 ADSL Service and Applications

ADSL is a broadband access technology, which uses high spectrum of standard copper wire in order to offer speeds up to 8 Mbps. ADSL stands for the *A*symmetric *D*igital *S*ubscriber *L*ine and is a part of technologies defining data transmission technologies over a copper wire. This group of technologies is generally represented by the terms *xDSL* or simply *DSL*. DSL technologies listed by DSL Forum are shown in Table 2.

Table 2: DSL Family Products Listed by DSL Forum [7]

Family	ITU	Name	Ratified	Maximum Speed
ADSL	G.992.1	G.dmt	1999	7 Mbps down, 800 kbps up
ADSL2	G.992.3	G.dmt.bis	2002	8 Mb/s down, 1 Mbps up
ADSL2plus	G.992.5	ADSL2plus	2003	24 Mbps down, 1 Mbps up
ADSL2-RE	G.992.3	Reach Extended	2003	8 Mbps down, 1 Mbps up
SHDSL	G.991.2	G.SHDSL	2001	5.6 Mbps up/down
VDSL	G.993.1	Very-high-data-rate DSL	2004	55 Mbps down, 15 Mbps up
VDSL2	G.993.2	Very-high-data-rate DSL 2	2005	100 Mbps up/down

[7] Retrieved from **http://www.dslforum.org** on 15.11.2006

There are two bandwidth figures in ADSL defining the downstream data rate and upstream data rate. The asymmetry in these two figures suggests the idea that a residential user is more likely to retrieve (download) information rather than send (upload) information (Kurose & Ross, 2003).

Each DSL technology defines how the available bandwidth is structured and how much bandwidth is provided (Kaplan, 2000). DSL uses frequency division multiplexing and divides the bandwidth into 3 different frequency bands:

- Telephony channel (POTS) in the 0-4kHz band
- Upstream channel in the 4-50kHz band
- Downstream channel in the 50kHz-1Mhz band

In order to understand the underlying technology, DSL network can be reduced to a number of distinctive parts. The logic behind this is to clarify the understanding of the service as well as the cost methodology and allow the model to have a degree of abstraction. The notion of such an abstraction is widely used as a basis for the regulators approach to broadband services in Europe. The model proposed by European Regulators Group[8] (ERG) for bitsream access (Figure 11) will serve the foundation of network topology (European Regulators Group, 2004).

[8] The European Regulators Group ("ERG") was created by European Commission Decision 2002/627/EC adopted on 29 July 2002. ERG is an independent body of regulators which acts as an interface between regulators and the Commission.

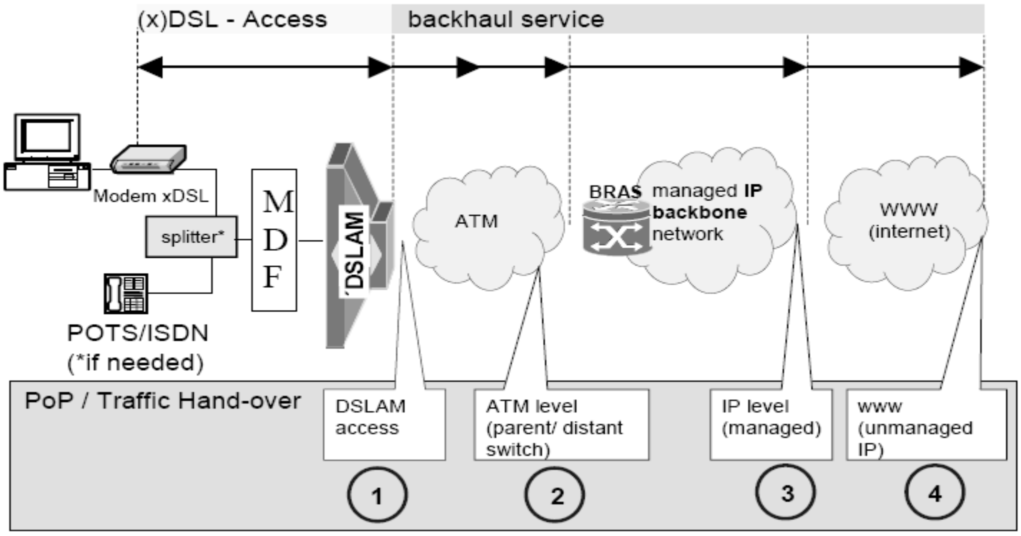

Figure 11: DSL Bitstream Access Topology[9]

Providers of DSL service are generally the incumbent telephony operators, such as Deutsche Telekom, France Telecom, Türk Telekom. This is due to the fact that the access network, which means the copper wire between the subscriber and the nearest telecom operator building, is a property of telephony companies and the DSL technology is located in this area.

Connection to the Internet via ADSL requires a series of network components. Connection to a port is established at the nearest local switch with a copper wire. At the local switches *DSLAM*, a bunch of ports are located. DSLAM is a network device, usually located at a telephone company's building that receives signals from DSL customers located in that area and aggregates the signals on a high-speed backbone line using multiplexing techniques. The port at the customer location and the port at the DSLAM are said to be communicating or *handshaking*. Each customer uses a single card and regardless of the access speed, cards are the same.

[9] ERG (2005)

Between DSLAM and BRAS, various protocols are used. In order to connect the users at the IP (Internet Protocol) level, generally ATM based network is used. ATM, Asynchronous Transfer Mode, is a packet switched technology using virtual circuits. DSL Forum (2001) lists 4 types of protocols used at this level for ATM/DSL Networks:

1. PPPoA/AAL5
2. IP/Ethernet/AAL5
3. PPPoE/Ethernet/AAL5
4. IP/AAL5

Although ATM has complete solutions to form end-to-end networks, IP has dominated the network applications. Since ATM is a network, which has been widely deployed by the most incumbent telephony operators, it operates as a transmission facility. ATM is able to give priority or some guarantee to subscribers like a CBR (committed bit rate) or VBR (variable bit rate)[10]. DSL itself is based is on ATM technology and thus can provide some sort of quality at the access level and easily incorporates with the legacy ATM networks. One of the key benefits of this incorporation for operators is the cost savings from additional investments (Minoli, 2003). If ATM access switches needed for transmission are not in the same building of the DSLAMs, other types of transmission like SDH are utilized (DSL Forum, 2001).

Newer types of DSLAMs are IP compatible and there is no need for ATM as a transmission network. Services operating under Internet Protocol such as IP Telephony and IP TV are easier to provide in such infrastructures. According to Dittberner's report (2006), IP DSLAM shipments constituted 57% of DSLAM ports. Internet Protocol is the dominant technology and is evolving into operating over physical layer, where SDH and ATM are currently the dominant technologies. Although Internet has evolved over the best effort approach, where no quality

[10] CBR: ATM service category with constant bit rate allowing continuous flow of data with strict bounds on delay and jitter (delay variation). VBR: ATM service category of variable bandwidth with average and peak traffic parameters (Minoli, 2003).

guarantees have been proposed, recent developments show a movement toward offering quality extensions in IP networks (Kurose & Ross, 2003).

3.2 ADSL Service in Europe and OECD Countries

ADSL has become the primary broadband Access medium in Europe and Figure 12 shows that the DSL technology dominates Europe broadband market.

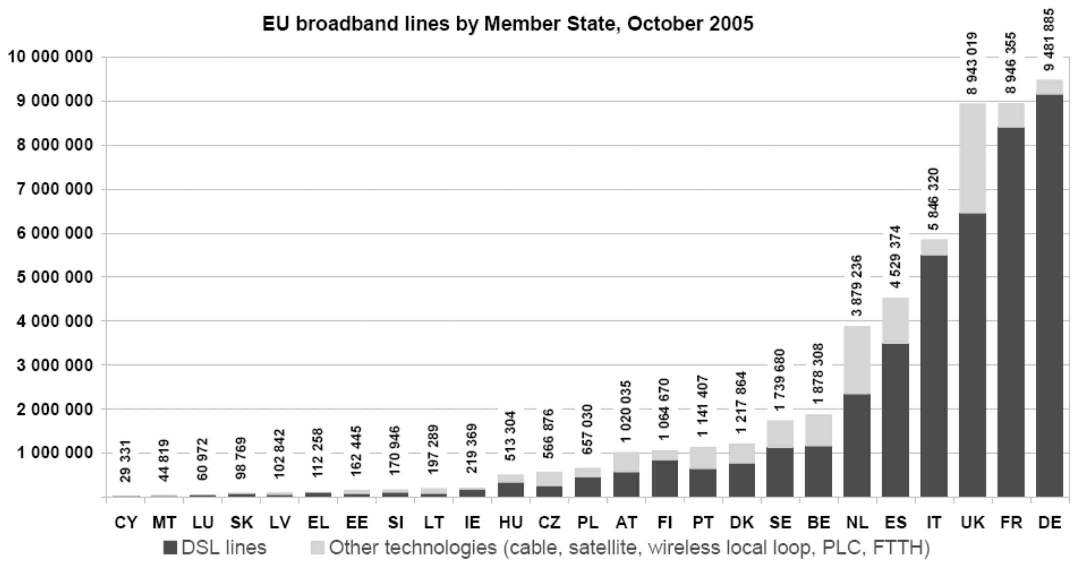

Figure 12: Broadband Access Lines in Europe [11]

According to the 11th implementation report by European Commission (2006), 80.4% of the total broadband access lines are DSL, whereas only 16.8% are provided by cable in member states of EU.

According to the OECD statistics (2006), DSL is also the leading platform in 28 of the 30 OECD countries with 63% of total subscribers. Cable access penetration is about 29% in OECD countries and only in USA and Canada, cable subscribers outclass DSL subscribers (OECD, 2006). Some of the OECD broadband statistics are represented in Appendix A.

[11] European Commission (2006)

One of the key trends in Europe (and the rest of the world) is the liberalization of communications market. This trend has implications on the broadband market as well. One of the reasons that DSL presided over other mediums is that copper network is the largest and oldest deployed communications infrastructure (Humphreys & Simpson, 2005). Using this already deployed infrastructure is a substantial cost saving for the operators. Indeed, the local loop, which means the copper wire between the subscriber and operator, is one of the obstacles for new operators as the cost of deploying a copper network is economically infeasible as there is already a deployed one. According to Minoli (2003) Broadband development is marked by two facts:

1. Incumbents invest in broadband services in order to increase their revenues to compensate the loss from voice service.
2. Digitalization process led to more services like VoIP and other value added services.

An important consequence of liberalization in the communication sector has been the division of networks in order to create new players in the markets. This division is represented in Figure 11. The process, from where new operators compete on a service base to infrastructure base is defined as the ladder of investment (Cave, 2003). Regulators often aim to encourage new entrants to climb the ladder of investment by regulating access to the incumbent’s network. There are 3 levels of service offerings for new operators:

1. Resale: All service is provided by the incumbent operator (represented by 1, 2, 3, 4 in Figure 11) and reseller (alternative operator) only performs marketing functions.
2. Bitstream: Incumbent operator lets the traffic to the service provider at points 1, 2 or 3 in Figure 11. The service provider establishes some of the infrastructure (like a managed IP network). This offer is more useful for the service provider as there is a chance to provide some sort of service differentiation.

3. Unbundling: There are two versions of unbundling: full unbundling and shared access. The former one lets the operator rent the local loop (shown as access in Figure 11) from the incumbent operator for a monthly fee. This means that the subscriber becomes an alternative operator's subscriber and both telephony and data services can be provided by the alterative operator. Shared access, on the other hand, lets only the higher spectrum of the local loop for data services to be used by the alternative operator.

3.3 ADSL in Turkey and Türk Telekom's ADSL Offer[12]

ADSL service has been provided by Turk Telekom as early as 1999 to a number of about 10,000 customers. Until the end of 2003, customer base remained about 60,000 customers, as there was no extra buying of DSL ports. At the end of 2003 company installed additional ports and made reductions in the ADSL prices to expand the customer base. During 2004 and 2005, ADSL service was aggressively promoted by Türk Telekom. From July 2005 Türk Telekom also started to offer ADSL as a point-to-point service and launched another DSL product, G.SHDSL, which provides symmetric connections up to 2 Mbps and Metro Ethernet connections for business users with access speeds from 5 Mbps to 1 Gbps. Figure 13 represents the cumulative ADSL subscriber number between December 2003 and June 2006. Accordingly in two years (2004 and 2005), yearly compounded average growth rate equals to 524%.

[12] This section is based on the company information.

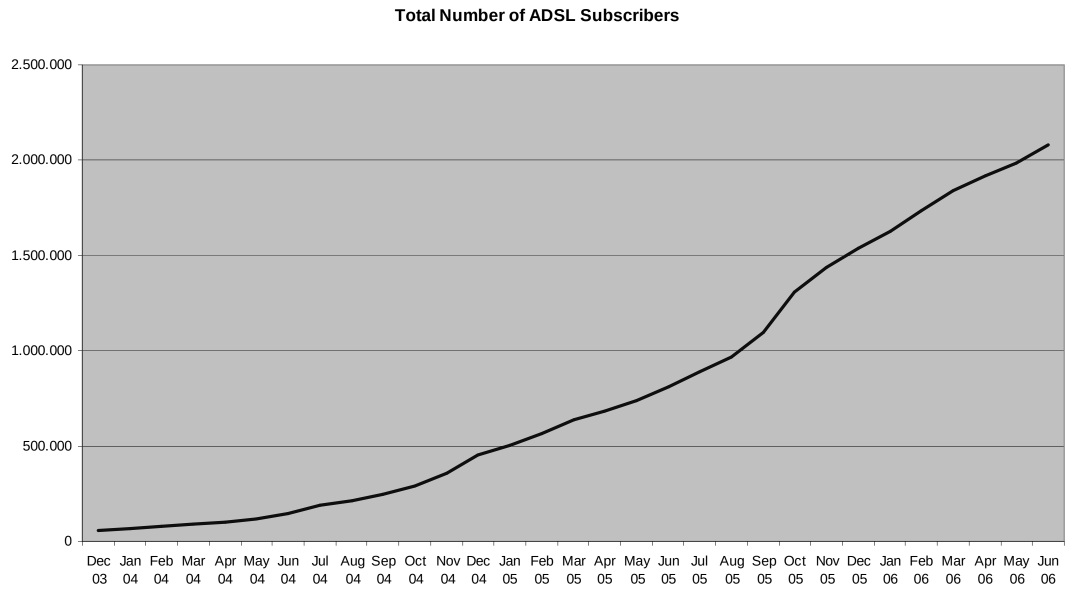

Figure 13: Cumulative Number of ADSL Subscribers.

From a lifecycle perspective, Türk Telekom's ADSL Internet service is in the growth stage as of 2006. The weekly sales figure has been going around 20,000-30,000 for the months after the promotion made in July-November 2005 (Figure 14).

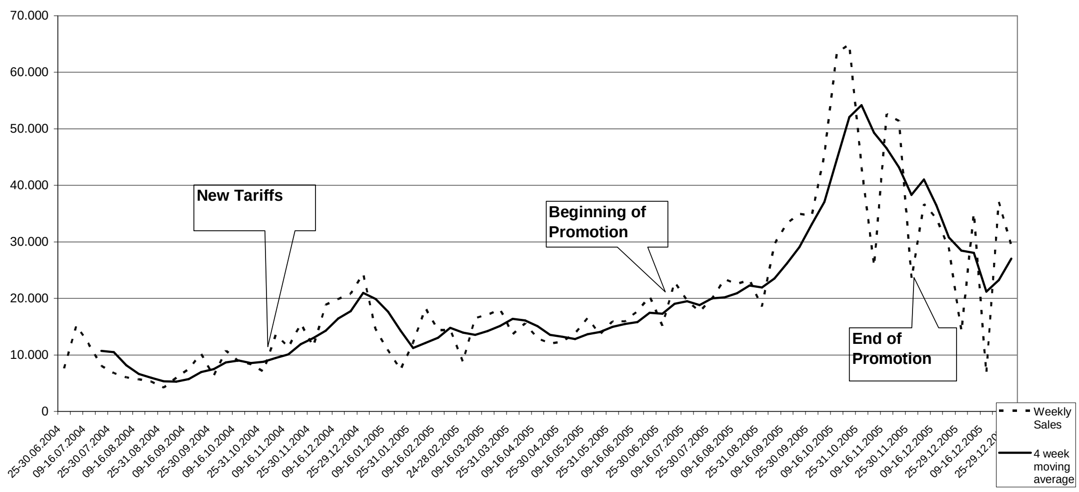

Figure 14: Weekly New Subscribers Normalized as 4 Week Moving Averages.

The architecture of the Türk Telekom DSL network is very similar to the topology offered by ERG. Between DSLAM and BRAS, PPP over ATM or PPP over

Ethernet protocols are utilized, where the former is more widely used. As the current IP Infrastructure has been upgraded to be MPLS based, the current topology reflects the one shown in Figure 15.

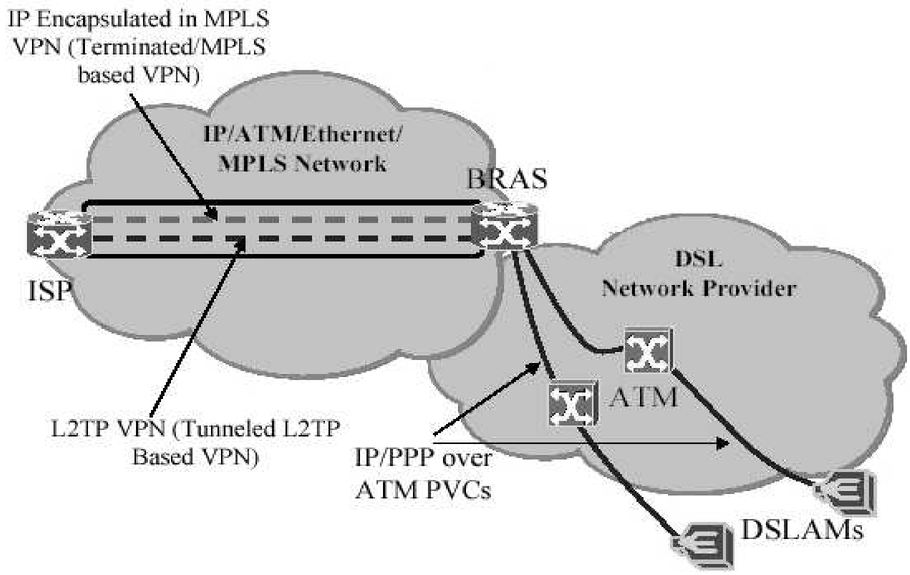

Figure 15: Current Türk Telekom DSL Topology[13]

From the customer's end device, traffic is carried over the PPPoE or PPPoA on the ATM PVC connection as VBR to the BRAS. The BRAS then tunnels the PPP traffic to the ISP using L2TP (DSL Forum 2004). L2TP is used together with PPP to transport packet streams on a single connection (Star, Sorbara, Cioffi & Silverman, 2003).

Türk Telekom has completely replaced it IP level infrastructure with a MPLS network in 2006. Although until the last quarter of 2006, MPLS based network was not utilized to offer new services, Türk Telekom is planning to offer services such as IPTV on this network beginning from 2007. Further plans include the replacement of the DSLAMs with new generation IP DSLAMs, through which a variety of multimedia services can be offered and cost savings can be made with the abandonment of carrier (ATM) networks. Türk Telekom is planning to offer such

[13] DSL Forum (2004)

services over higher speed ADSL access (4 Mbps) and trying to improve its access network.

3.4 Tariff Structure of Türk Telekom

Türk Telekom started to offer ADSL service with the following access speeds in 1999:

- 128 / 32 Kbps
- 256 / 64 Kbps
- 512 / 128 Kbps
- 1028 / 256 Kbps
- 2048 / 512 Kbps

The tariff structure was two-part: For the first 60 hours a month, a monthly fixed fee and for each hour above an hourly fee was charged. However, in the beginning of 2001 Türk Telekom started to apply flat rate tariff with a monthly fixed charge.

In September 2004, Türk Telekom abolished 128 / 32 Kbps offer and migrated all the customers to the 256 / 64 Kbps offer. At the same time, quota restricted offers were introduced (256 / 64 Kbps with 3 GB download and 512 / 128 Kbps with 5 GB download) and the connection fees, which were the same as the monthly fees, became equal.

In September 2005, 256 / 64 Kbps with 3 GB download offer was upgraded to 512 / 128 Kbps with 3 GB download and 512 / 128 Kbps with 5 GB download offer was upgraded to 512 / 128 Kbps with 6 GB download. An offer of 512 / 128 Kbps with 9 GB download was also introduced.

In August 2006, capped customers of 512 / 128 Kbps offer were migrated to the 1024 / 256 Kbps speed with the same data quotas. Also, 256 / 64 Kbps customers were offered a period of six months trying the 1024 / 256 Kbps with 6 GB download without paying the over limit fees. As of October 2006, number and distribution of customers are illustrated in Table 3.

Table 3: Number and Distribution of Customers

Offer Type	*Number of Customers*	*Ratio*
256/64 Kbps	317.096	13,5%
512/128 Kbps	62.640	2,7%
1024/256 Kbps	34.061	1,4%
2048/512 Kbps	34.514	1,5%
1024 Kbps /w 3 GB download	1.827.722	77,7%
1024 Kbps /w 6 GB download	71.619	3,0%
1024 Kbps /w 9 GB download	4.048	0,2%

Türk Telekom defines its tariffs on a cost basis method. However, its tariffs are approved by the Telecommunications Authority according to the market conditions and competitive concerns. After privatization in 14 November 2005, according to the Competition Authority decision, Türk Telekom was obliged to transfer retail level Dial Up and ADSL service to a subsidiary of its own in 6 months after the privatization. Accordingly, in the beginning of June 2006, Türk Telekom has transferred the retail level ADSL service to its subsidiary TTNet. As late as August 2006, almost 99% of ADSL subscribers have been TTNet customers. Of the service offering options for new operators, only resale and bitstream options are available. Operators including TTNet offer ADSL Internet service only with the resale option. Appendix G and Appendix H include Türk Telekom tariffs and a comprehensive list of tariffs from several European countries, respectively.

CHAPTER 4

PROPOSED PRICING MODEL

The proposed pricing model takes the price level as an input. Given the market demand curve, the demand level and the costs are determined according to the price level. For each price level, revenue and cost figures determine the profits and prices maximizing the profits are chosen.

The price level may not coincide with the real situations. For example, the price elasticity might be at a level that corresponds to increasing revenues as prices rise. Yet such a policy of increasing prices might affect the public image of a company acting as the sole provider of the service and expecting a competitive attack from potential firms. Additionally pricing must be in line with the international benchmarks, as NRAs use these figures for observing and regulating the markets. Also regulatory efforts restricting the actions of significant market power operators should be taken into account.

The restrictions mentioned above can be put into a pricing model and can form a boundary for a possible set of prices. However it shall always be kept in mind that in a multiple domain environment like Internet, optimal pricing may not scale well. This is due to the huge amount of information needed to find an optimal solution. Still, there is much value for strategists to gain from a set of prices (Li, Iraqi & Boutaba, 2004).

The context under which the proposed pricing model operates is depicted in Figure 16.

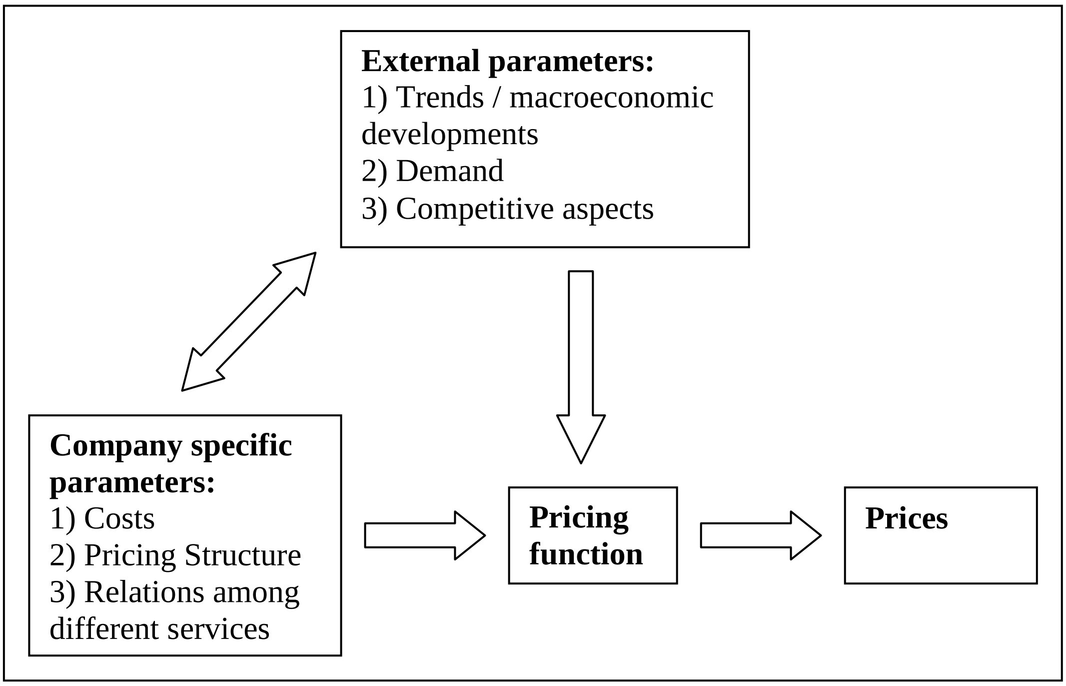

Figure 16: Context of Pricing

There are many concerns affecting the determination of prices, and there are cross-effects among these concerns. The model assumes costs and demand level as its main drivers. There are other concerns like the competitive level, macroeconomic concerns (interest rate) affecting the pricing of services. However, these can easily be appended to the model as probabilistic inputs. Furthermore, as the model is for a monopoly, the profit maximization scheme can easily be converted according to a competitive firm. For the sake of brevity, some of the variables are kept out of the model or only partially included. Figure 17 represents the model with its inputs and outputs.

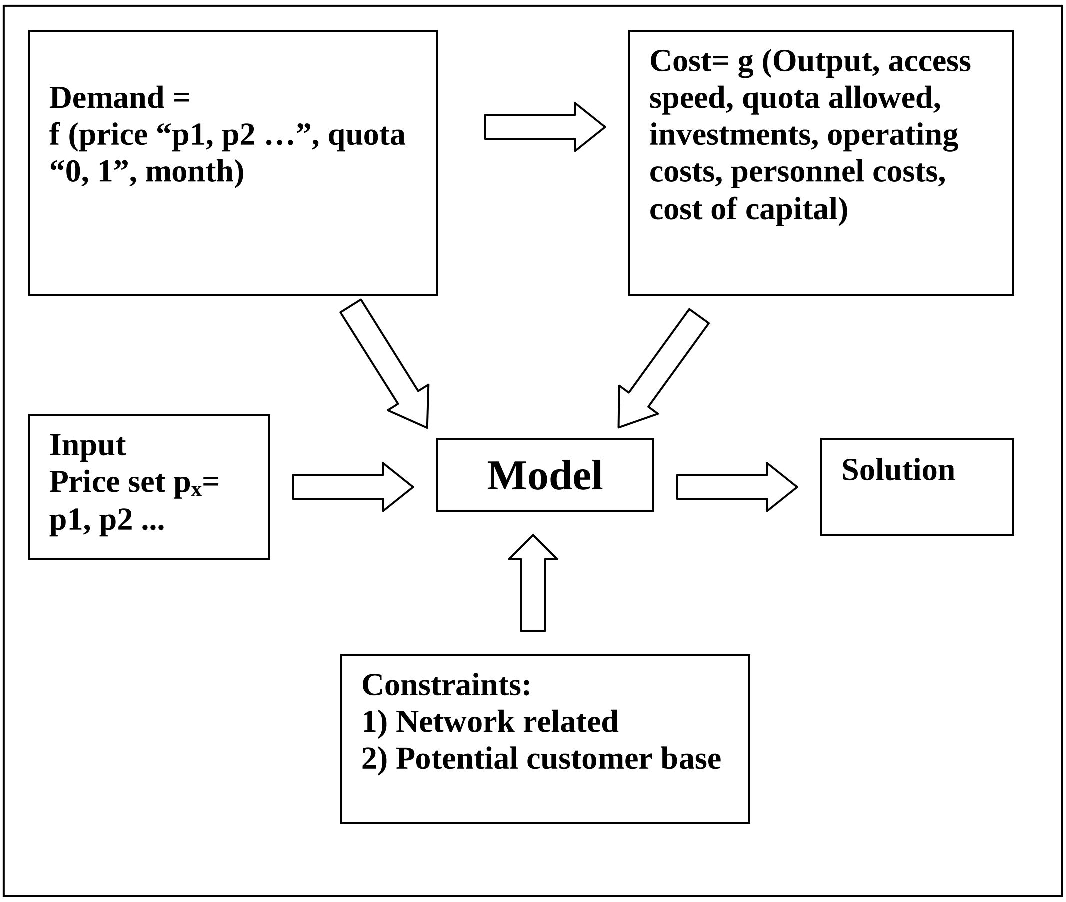

Figure 17: Context of the Proposed Pricing Model

The pricing model is purely economic in the sense that it explores the problem from a single time period and does not take into account the changes in the customer base. The operation of the overall model with its modules is depicted in Figure 18. Sections 4.1, 4.2 and 4.3 define modules of the model: demand function, cost model and the optimization function. The chapter ends with a discussion of the results of the proposed model.

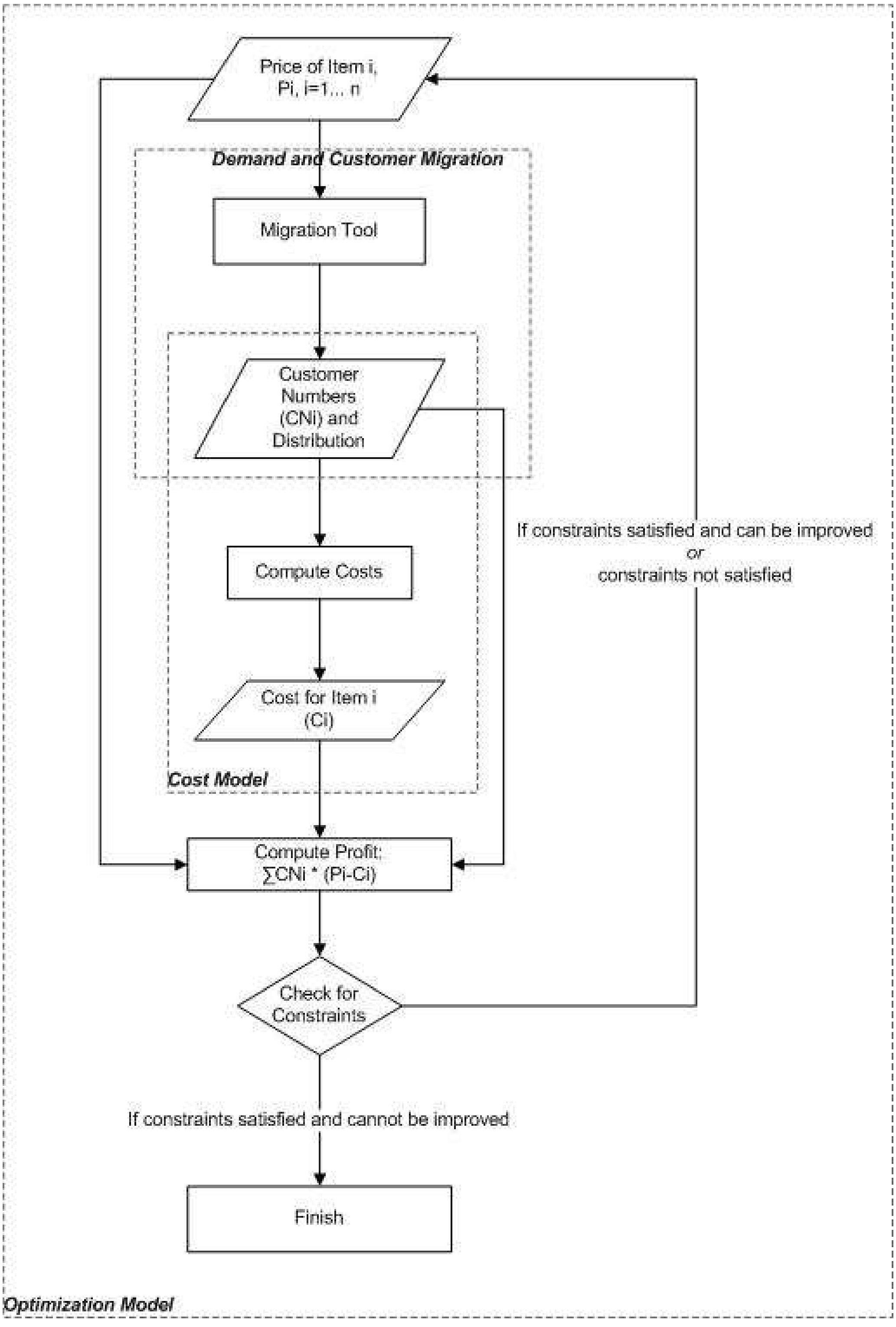

Figure 18: Operation of the Proposed Pricing Model

4.1 Demand Function

Demand for broadband services has been investigated by various researchers during the last decade (Rappaport, Kriedel, Taylor & Alleman, 2003; Cerno & Amaral, 2005). These works consider price, demographic information (household size, education, age, and gender), income, availability of service and price of alternative services as indicators of demand.

For the scope of this thesis, the following assumptions are made:

1. The ADSL service is virtually covering all areas of the country, where PSTN is available.
2. The market of alternative services is negligible when compared with the ADSL service:
    a. Dial Up subscribers are diminishing at a rate of 50% per year. In 2 years time TT dial up subscriber base has been reduced from above 300,000 to under 100,000 (see Appendix B for development of TTNet Dial Up subscribers)[14]. Moreover these two services are not directly comparable, as ADSL offers a minimum of 4 times bandwidth when compared to Dial Up's 56 Kbps offer.
    b. Cable TV Internet service, which is near perfect substitute of ADSL Internet service is believed to have a market of about 40,000 subscribers, which corresponds to less than 2% of the ADSL market[15].
3. Demand is defined as a function of price, presence of quota in tariff and a time series component. Definition of demand as a function of price is a conventional method in demand analysis (Goolsbee, 2003). Other service characteristics like access speed and connection fee are found to be insignificant after stepwise regression. This can be explained by the fact that the related data included both the residential and business customers, which

[14, 15] Source: Türk Telekom unofficial internal data.

hindered the value of access speed for particularly business customers. High prices of the higher access speed might also have impeded the value of the access speed.

4. Real income of households, which is the nominal (monetary) income adjusted for inflation and purchasing power parity, is generally defined by long term contracts (Begg, Fischer & Dornbusch, 2001). Since the proposed model focuses on the short run, it is assumed that the income level is constant. Additionally monthly income figure for the period investigated in the model (December 2003-November 2005) is difficult to find as annual or quarterly figures are generally published by the states.

Log linear models are the most common types of demand functions. In the log linear models, demand is scaled to the percentage change, not the absolute change in price (Levenbach & Cleary, 2005). One percent change in the log of a variable (Price) corresponds to the percentage change in the dependent variable (Qdemanded). Thus these coefficients can be interpreted as the elasticity coefficients. The demand function is defined as follows:

$$\ln(\text{Qdemanded}) = \alpha_0 + \alpha_1 * \ln(\text{Price}) + \alpha_2 * \text{Data Limit} + \alpha_3 * \text{Time} \tag{4.1}$$

By using the 2003 December-2005 November monthly data (see Appendix C for details) on consumer number and tariffs[16], the following coefficients are determined:

$$\ln(\text{Qdemanded}) = 17.0 - 2.09 \ln(\text{Price}) + 1.88\ \text{Limit} + 0.0942\ \text{Month} \tag{4.2}$$

In order to have a better understanding of independent variables' effect on the dependent variable, the regression function is also lagged one and two periods (months) behind. The rationale behind this is clear that the market's response to

[16] Due to changes made to tariffs in September 2004, the customer information figure for September and October 2004 are not detailed enough. As a result these months are omitted in the analysis.

changes in price or other independent variables may not be immediate. In all cases, adjusted R^2 figure was not changed significantly. Yet simultaneous period figures showed better t statistics and satisfied the regression assumptions more fully than the cases where independent variables were lagged. Appendix C includes the detailed analysis of the regression model. All regression assumptions except normality and constant variance assumptions are satisfied. Since only the elasticity estimate is used in the proposed model, violation of these assumptions is not critical (Miles & Shevlin, 2001).

4.1.1 Interpretation of the Demand Function

The crucial figure in the demand function is the coefficient of price (-2.09) or price elasticity of demand. This shows that the demand for ADSL is elastic, which is the predictable case for technological products or services. Price elasticity figures from various studies are shown in Table 4.

Table 4: Price Elasticity Figures for Broadband[17]

Study Name	Country	Elasticity figure
Goolsbee (1998)	USA	Between -2.15 and -3.76
Varian (1998-1999)	USA	Between-1.3 and -3.1
Rappoport (2003)	USA	Range of -1.0
Rappoport (2001)	USA	-0.47
Rappoport et. al. (2000)	USA	Between -1.4 and -1.5 for ADSL and Between -0.6 and -0.8 for Cable

Following remarks can be made about the price elasticity figure in Equation 4.2:

- GDP per capita of Turkey is well below the developed countries, thus consumers are more responsive to prices. Also, in demand functions income

[17] Goolsbee (2003)

level of consumers (for example per capita GDP) is generally accounted for. As the model does not have an income variable, the estimated price elasticity (coefficient) may also be confounded by the effect of income elasticity, which the model fails to isolate.

- DSL or in more general terms broadband services are still in the growth in stage in Turkey. As price sensitivity is generally higher in the new products, broadband price elasticity is likely to decline overtime. A study held by Burton and Hicks (2005) in West Virginia, USA shows that absolute value of price elasticity for broadband has declined to near 0 from a level of 2.5 in 7 years.
- Cross price effects of dial up and cable services are not accounted for due to the unavailability of past price data of the operators. Although these alternative services do not account for a large share of the market, including their prices in the model may decrease the price elasticity of ADSL demand. Furthermore, the effect of advertising is not explored in the model. Generally, marketing activities cause price elasticity to be lower. Since marketing activities are not covered in the model, it is only natural that the estimated price elasticity turns up to be high.
- Whereas users are sensitive to higher prices, declining prices affect the price sensitivity figures, marked by a movement to the inelastic part of demand curve. Rappoport's studies show that broadband is becoming a necessity good from that of luxury category (Crandall, 2003). In Turkey ADSL may still be a luxury good, therefore higher price elasticity is observed.

Another independent variable, data limit, has a positive coefficient. This figure is reasonable in the sense that higher data limits are generally positively perceived by the users, which relaxes a restriction on the usage. Time series variable, month, reflects the increase in customer base.

4.1.2 Migration Tool

It is expected that a change in a tariff plan brings changes in the position of customers. A migration plan shows the path how customers might behave in changes made in the components of a tariff. An economic model (migration tool) using the price elasticity figure in demand function (Equation 4.2) with certain assumptions has been developed to allocate customers to different packages upon a price change. Operation of the tool is illustrated by the algorithm shown in Table 5.

Table 5: Migration Algorithm

```
// Begin
For each option

        If option is quota restricted

                Look for alternative beginning from highest access speed option where
[(alternative access speed >= speed option i) and (quota >= quota option i) and (alternative
price <= 1,1 * price option i)]

// Look for an alternative which has better characteristics in terms of product characteristics.
//Third restriction (10% margin) is put in order to give more flexibility to the model.

                If such alternative exists move customers to the alternative package.

                        Customer number of alternative option = (New customer number i -
Old customer number i) * [ (Alternative Option Price - Old Price i ) / (Old Price i ) * Price
Elasticity] + Customer number of alternative option

                If not exists

                        If change in price is larger than 20% // Assuming that customers
remain indifferent to the increases up to 20%.

                                New customer number i = Old customer number i * (Change
in Price i – 20%) * Price Elasticity

                        Else

                                New customer number i = Old customer number i * Change
in Price i * Price Elasticity


        If option is not quota restricted

                Look for alternative beginning from highest access speed option where
[(alternative access speed >= speed option i) and (alternative price <= 1,1 * price option i)]
```

Table 5 (cont.): Migration Algorithm

```
// Look for an alternative which has better characteristics in terms of product characteristics.
// Second restriction (10% margin) is put in order to give more flexibility to the model.

            If such alternative exists move customers to the alternative package.

                  Customer number of alternative option = (New customer number i - Old customer number i) * [ (Alternative Option Price - Old Price i ) / (Old Price i ) * Price Elasticity] + Customer number of alternative option

            If such alternative not exists

                  If change in price is larger than 20% // Assuming that customers remain indifferent to the increases up to 20%.

                        New customer number i = Old customer number i * (Change in Price i – 20%) * Price Elasticity

                  Else

                        New customer number i = Old customer number i * Change in Price i * Price Elasticity


// End
```

The migration tool allocates the customers to the new packages. It can abolish certain packages, which remain obsolete upon tariff changes. Although price reductions are very common in technological goods or services, service providers try to keep their ARPU figures by offering services with more value. In this sense, increasing the access speed while keeping the price constant is one of the strategies to keep ARPU constant.

Allocation of customers to the packages is established for the interest of the customers according to the following rules:

- Customers can be moved to a package having at least the current access speed.
- Customers cannot be moved to the packages having lesser quota than their current quotas. This means that customers subscribed to offers having no quota limit cannot be moved to offers with quota.

It is assumed that customers remain indifferent to the price increases up to 20% and customers can be allocated to another package with a price 10% above the current prices they are currently paying.

4.2 Cost Model

The cost model[18] uses fully distributed cost (FDC) methodology together with bottom-up and top-down approaches. By using a bottom-up approach, it includes the underlying logic of deterministic principle in cost allocation and is a good indicator of cost in spite of its simplicity. Although relying on assumptions, one key benefit of bottom-up approach is that it assumes the efficiency of the operator. For example, in the model it is assumed that for leased lines as a transmission component, the cost-based wholesale tariff of Türk Telekom is utilized. Such use of transfer pricing is especially useful for consistency and transparency of service provision. In Andersen's (2002) report, it is stated that "The level of transfer prices must be equal to the price used to sell the service/product externally." By using transfer prices, some of the joint infrastructure (such as the local loop and transmission) is priced efficiently (Ekergil, 2006).

The model includes the following components:

- Copper (Access or local loop)
- DSLAM (DSL Infrastructure)
- Backbone infrastructure
- Internet
- International Lines
- Personnel
- Building and Operating Costs
- Cost of Capital
- General and administrative costs and billing costs.

[18] Cost model is prepared in Excel™, which is a common practice.

Regarding the above components, assumptions and data used is described below. Unless mentioned otherwise, figures represent the assumptions and data used by Türk Telekom.

1. Access cost is defined as ½ of the Türk Telekom's main PSTN tariff's monthly rental fee (StandartHATT monthly rental rate is 11.5 TL including taxes). According to the European Electronic Communications Regulation and Market Report by the European Commission (2006), shared access is generally defined as a rate between ⅓ and ½ of the full unbundled access in Europe. However, as all ADSL subscribers must be PSTN subscribers, this cost is excluded in the model.
2. The cost of each port is assumed to be reducing due to economies of scale.
3. In line with company information, economic life of some of the network components are:
    a. DSL infrastructure: 5 years
    b. ATM and IP infrastructure: 7 years
    c. Fiber Network (including international lines): 15 years
    d. Building: 25 years

    Similarly the personnel numbers are defined according to the total number of subscribers reflecting the current personnel – subscriber number ratios:
    a. A DSL technical personnel for each 3,000 subscribers
    b. Transmission backbone personnel for each 10,000 subscribers
    c. Internet personnel for each 50,000 subscribers
    d. Customer service personnel for each 10,000 subscribers.
4. Contention ratio of 1:18 is assumed according to the Türk Telekom's proposal to Telecommunication Authority for Bitstream Access Tariff. Contention ratio is "a measure of the maximum number of users who simultaneously share a DSL broadband connection between their local exchange and the main Internet gateway" (Ofcom, 2006). For example, British Telecom offers 1:20 for business customers and 1:50 for residential customers. KPN of Netherlands offers contention rates changing from 1:1

(for symmetric DSL connections) to 1:20[19]. Further examples of contention ratios are explored by Wairua Consulting (2006) and are shown in Appendix D.

5. Since much of the Internet content is located abroad, approximately 70% of IP traffic from transmitted abroad[20].
6. Since there is very little factual data regarding the use of network according to access speed and data limit imposed on subscribers, more weight is provided to the access speed (80%) over usage (20%) when allocating costs, as the tariff structure is primarily based on access speed. The change in cost resulting from doubling the access speed is assumed to be same as the figure present in the leased line tariffs (approximately 1.45). Usage values as of September 2006 and estimated usage distributions are represented in Appendix E.
7. Billing cost is assumed as 0.75 TL per subscriber. This includes printing, enveloping and distribution of the bills.
8. General and administrative cost is assumed as 1.5 TL per subscriber according to the balance sheet figures from 2005. General and administrative costs include items that cannot be associated to the service directly. Examples of these are personnel in accounting or legal activities, infrastructure used commonly for services as accounting, customer relations management, office equipments.
9. The weighted average cost of capital (WACC) is taken as 14.90% for USD and 26.24% for TL investments. WACC is “the cost of capital on the firm’s existing projects and activities” (Ross, Westerfield & Jaffe, 1999). Detailed discussion of WACC and its calculation is provided in Appendix F. Valuation of investments is done using annuity calculation with yearly amortization rate equal to $\frac{WACC}{[1-1/(1+WACC)^n]}$ (Meigs et. al., 1999), where n defines the economic life of the investment.

[19] Retrieved from http://www.kpn-wholesale.com on 14.11.2006
[20] Source: Türk Telekom unofficial internal data.

10. Other cost items are assumed to be negligible and 2% margin is added to the overall cost to cover the risk of the uncollected bills.
11. Türk Telekom has to pay 18% Value Added Tax (VAT), 15% Special Communications Tax (SCT) and 1% Communications Tax (CT) to the state. VAT and SCT are calculated from the tax excluded prices and are paid by the end users. On the other CT is calculated as 1% of the tax excluded price and is paid to the Ministry of Transportation. Thus, the total tax burden on subscribers is approximately 34.34% ($[1.0101 \times (1.18 + 1.15) - 1]$%).
12. TL/USD conversion rate is fixed at 1.5.

According to the assumptions made, ADSL network is divided into different parts (Figure 19) in order to clarify cost components. *Local loop* consists of the copper access and the MDF (main distribution frame). MDF and DSLAM are located in the same building. The customers are then multiplexed into 2 Mbps, 34 Mbps or 155 Mbps lines according to the customer density in the area. According to the availability of the ATM network, these customers are transported to the nearest ATM switches. *ATM Network* operates as a backbone facility to carry the user data to the *IP based national network* operating at the core. In a sense ADSL operates in an IP-over-ATM-over-SDH environment. In Figure 19, international part of the network is represented by the *cloud*. Cloud also represents the other operators' networks as well as private ones.

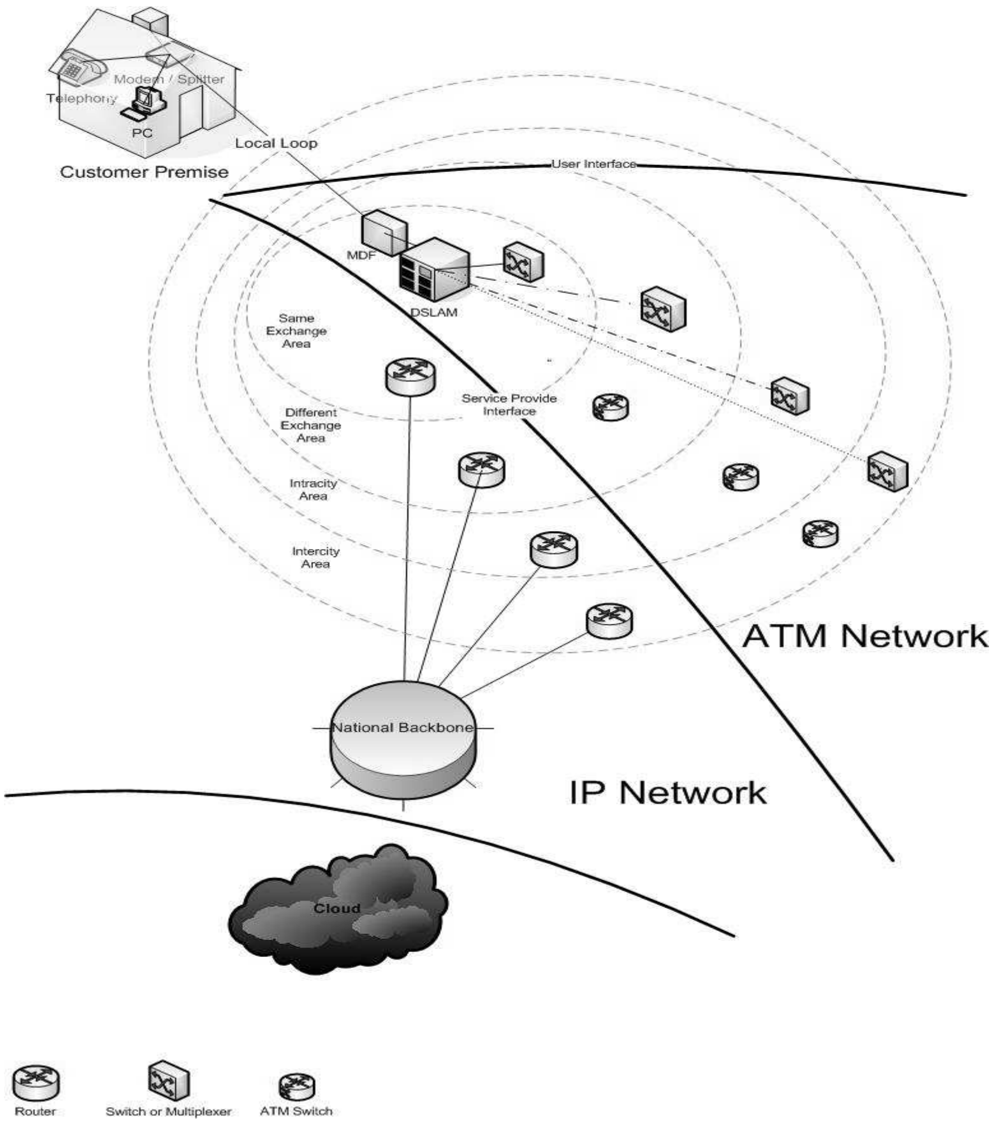

Figure 19: DSL Topology in the Context of Transmission Lines [21]

All cost components are then put under the context of the leased line tariff structure of Türk Telekom, which provides the necessary infrastructure for transmission. Türk Telekom's wholesale leased line tariff has 4 different area zones, namely same exchange, metropolitan, intracity and intercity (Figure 19). Leased line tariff of Türk Telekom has been the only tariff approved by Telecommunications Authority on a cost basis as of October 2006. Figures for the monthly rental rates of Leased Lines are provided in Appendix G.

[21] ERG (2005) and Star et. al. (2003)

The basic operation of the cost model is depicted in Figure 20.

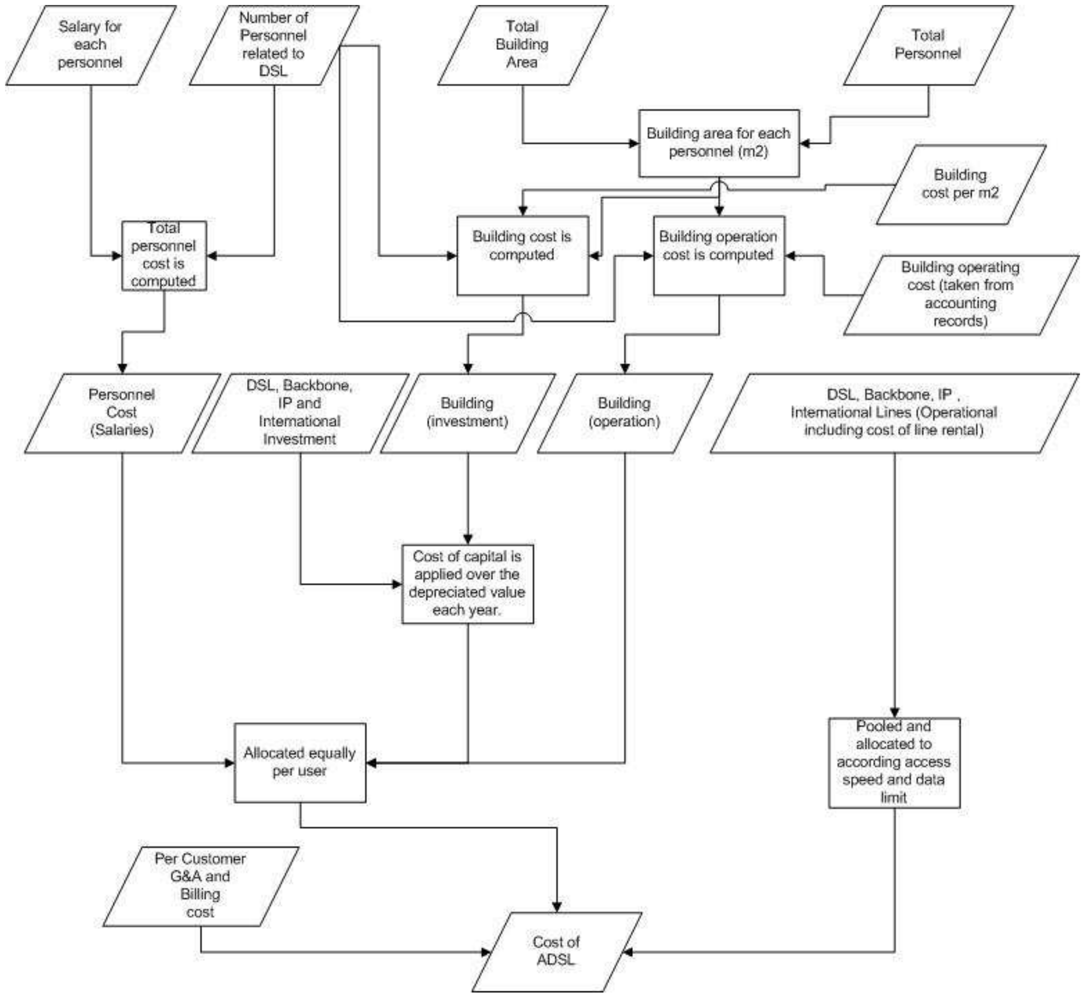

Figure 20: Cost Model

By inputting the October 2006 figures, cost figures shown in Table 6 are elicited from the model. From Table 6, it is seen that margins increase as the price of the offer increases. Whereas for the starter package (1024 Kbps with 3 GB), there is a loss of 8%, the higher priced packages have considerable profit margins, 53% for the highest priced offer (2048 Kbps). This demonstrates the evidence of subsidization among packages, where starter package is subsidized by the higher priced packages.

Table 6: Cost Items and Margins

Cost Item	*256 K*	*512 K*	*1024 K*	*2048 K*	*1024 K / 3G*	*1024 K / 6G*	*1024 K/ 9G*
Access	-	-	-	-	-	-	-
DSLAM Investment	2.55 TL	2.55 TL	2.55 TL	2.55 TL	2.55 TL	2.55 TL	2.55 TL
DSLAM Operating	2.97 TL	5.56 TL	10.36 TL	12.59 TL	4.70 TL	5.42 TL	6.07 TL
Backbone Investment	0.60 TL	0.60 TL	0.60 TL	0.60 TL	0.60 TL	0.60 TL	0.60 TL
Backbone Operating	3.10 TL	5.81 TL	10.83 TL	13.15 TL	4.91 TL	5.66 TL	6.34 TL
IP Investment	0.44 TL	0.44 TL	0.44 TL	0.44 TL	0.44 TL	0.44 TL	0.44 TL
IP Operating	2.70 TL	5.07 TL	9.45 TL	11.48 TL	4.29 TL	4.94 TL	5.53 TL
International Investment	0.31 TL	0.31 TL	0.31 TL	0.31 TL	0.31 TL	0.31 TL	0.31 TL
International Operating	0.86 TL	1.62 TL	3.02 TL	3.67 TL	1.37 TL	1.58 TL	1.77 TL
DSLAM Personnel	0.94 TL	0.94 TL	0.94 TL	0.94 TL	0.94 TL	0.94 TL	0.94 TL
DSLAM Building	0.34 TL	0.34 TL	0.34 TL	0.34 TL	0.34 TL	0.34 TL	0.34 TL
Backbone Personnel	0.14 TL	0.14 TL	0.14 TL	0.14 TL	0.14 TL	0.14 TL	0.14 TL
Backbone Building	0.05 TL	0.05 TL	0.05 TL	0.05 TL	0.05 TL	0.05 TL	0.05 TL
IP Personnel	0.06 TL	0.06 TL	0.06 TL	0.06 TL	0.06 TL	0.06 TL	0.06 TL
IP Building	0.02 TL	0.02 TL	0.02 TL	0.02 TL	0.02 TL	0.02 TL	0.02 TL
Sales Personnel	0.28 TL	0.28 TL	0.28 TL	0.28 TL	0.28 TL	0.28 TL	0.28 TL
Sales Building	0.10 TL	0.10 TL	0.10 TL	0.10 TL	0.10 TL	0.10 TL	0.10 TL
Billing	0.75 TL	0.75 TL	0.75 TL	0.75 TL	0.75 TL	0.75 TL	0.75 TL
G&A	1.53 TL	1.53 TL	1.53 TL	1.53 TL	1.53 TL	1.53 TL	1.53 TL
Margin (%2)	0.35 TL	0.52 TL	0.84 TL	0.98 TL	0.47 TL	0.51 TL	0.56 TL
Sum	*18.10 TL*	*26.71 TL*	*42.61 TL*	*49.98 TL*	*23.86 TL*	*26.22 TL*	*28.37 TL*
Prices (inc. Taxes)	49.00 TL	89.00 TL	139.00 TL	229.00 TL	29.00 TL	49.00 TL	69.00 TL
Prices (exc. Taxes)	36.47 TL	66.25 TL	103.47 TL	170.46 TL	21.59 TL	36.47 TL	51.36 TL
Profit	18.37 TL	39.54 TL	60.86 TL	120.48 TL	-2.27 TL	10.25 TL	22.99 TL
Gross Margin % (Profit/Prices inc. Taxes)	***37%***	***44%***	***44%***	***53%***	***-8%***	***21%***	***33%***

Monthly profit and cost figures as of October 2006 are illustrated in Table 7. Although nearly 78% of customers are subscribed to the 1024 Kbps with 3 GB package (see Section 3.4), actual profit is coming from a rather smaller group of subscribers paying higher monthly fees.

Table 7: Monthly Cost and Profit Figures

Package	***Cost***	***Prices (exc. Taxes)***	***Number of Customers***	***Revenue***	***Cost***	***Profit***
256/64 Kbps	18.10 TL	36.47 TL	317,096	11,565,955 TL	5,739,511 TL	5,826,445 TL
512/128 Kbps	26.71 TL	66.25 TL	62,640	4,149,888 TL	1,672,987 TL	2,476,901 TL
1024/256 Kbps	42.61 TL	103.47 TL	34,061	3,524,251 TL	1,451,288 TL	2,072,963 TL
2048/512 Kbps	49.98 TL	170.46 TL	34,514	5,883,360 TL	1,725,121 TL	4,158,239 TL
1024 Kbps 3 GB	23.86 TL	21.59 TL	1,827,722	39,455,068 TL	43,607,211 TL	-4,152,143 TL
1025 Kbps 6 GB	26.22 TL	36.47 TL	71,619	2,612,276 TL	1,878,118 TL	734,158 TL
1026 Kbps 9 GB	28.37 TL	51.36 TL	4,048	207,914 TL	114,862 TL	93,052 TL
			2,351,700	***67,398,712***	***56,189,097***	***11,209,615***

4.3 Optimization Model

In sections 4.1 and 4.2, demand function and cost model are defined. The objective function of profit maximization can be represented as:

$$\text{Max [UnitDemanded (Price – Unit Cost)]} \qquad (4.3)$$

which is subject to a set of constraints. These constraints can be economic (the upper limit consumers are willing to pay, competition) or technical in nature (total customer capacity available, network constraints such as congestion). Some of these constraints are already deployed in the underlying cost model described.

Objective function of equation 4.3 is derived from Equation 4.2 and the cost model described in section 4.2. It can be seen that Equation 4.3 can be represented as:

$$Max\sum_{i=1}^{n}[\mathrm{Qdemanded_i} * (\mathrm{P_i} - \mathrm{C_i})] \qquad (4.4)$$

Where i is the service type defined in terms of access speed and data limit, Qdemanded is the demand found by a migration plan (see section 4.1.2), and C is the cost associated with the service found by the cost model (see section 4.2).

In Equation 4.4, price can be modified in order to find the solution to the maximization problem. For the scope of this thesis, service portfolio of Türk Telekom defining *access speed, quota restriction* and *connection fee* are held constant and kept at their current values. For revenue calculation monthly fees are used and above quota tariffs are not taken into account.

The following constraints are added to the model in order to come up with a tariff structure:

- $P_i > C_i$ *(price of offer i shall be greater than its cost to prevent cross subsidization)*
- $C_i <$ $Cost_{i+1}$ *(given access speed of offer i is lower than offer i+1)*
- $P_i * 0,82 > C_i$ *(as wholesale tariff is determined on a retail minus basis (18% below the retail level), wholesale tariff shall cover the costs)*
- $P_i > P_{i+1} * DiffR$ *(price for each offer shall be differentiated by a ratio)*
- $x < DiffR < y$ *(differentiation ratio definition)*
- $a < NC < b$ *(total Number of customers shall be greater than its current value "a", smaller than the capacity "b")*

Where,

- *DiffR* is differentiation ratio is between prices reflecting the changes in the variable costs, plus a margin needed for consumer perception to differentiate services. According to the international tariffs investigated (see Appendix H), *20% price differences* between service offers is assumed to be a ratio enough for differentiating the services, while the access speed doubles. This ratio is observed also as minimum change in the costs ADSL. For changes in download quota while holding the access speed constant, *10%* is assumed to be the minimum differentiation ratio. Upper limit for the services (*y*) are kept at *100%*.

- P_i is the retail price of the service excluding taxes (18% Value Added Tax, 15% Special Communications Tax and 1% Communications Tax).
- C_i is the total cost associated with service *i*.
- *NC* is the total number of customers.

4.3.1 Optimization Results

Optimization has been established on a spreadsheet application MS Excel™, where both cost and demand modules are located and where it is easy to alter the values of variables. MS Excel™ Add-in "Solver" tool uses the Generalized Reduced Gradient (GRG2) nonlinear optimization code. Because Solver uses a hill-climbing routine, the solution is sensitive to the initial values and to the usage of discrete values produced by the migration plan. Current values inputted as initial values did not produce feasible results. Instead of the current values, price for each offer is inputted as zero and Microsoft Excel Solver output satisfying all the constraints is obtained (Table 8).[22]

[22] A second run of the Solver (Evans, 2007) on the output provided in Table 8 improved the overall result with a slight increase of profit per month while the number of subscribers of the 2 Mbps offer reduced more than 50%. Since the latter solution has fewer incentives to promote higher access speeds and thus fits less to long term objectives (Section 3.3), the initial solution is analyzed in detail in the thesis.

Table 8: Excel Solver Output

Microsoft Excel 11.0 Answer Report

Target Cell (Max)

Name	Original Value	Final Value
NetProfit	- 157,908,828	18,561,947

Adjustable Cells

Name	Original Value	Final Value
Price256K	-	25.93
Price512K	-	35.06
Price1024K	-	53.90
Price2048K	-	77.97
Price1024K.3G	-	35.55
Price1024K.6G	-	39.32
Price1024K.9G	-	43.28

Constraints

Name	Cell Value	Status	Slack
Cost1024	29.31	Not Binding	3.58
Cost1024.3	21.17	Not Binding	0.53
Cost1024.6	22.20	Not Binding	1.81
Cost1024.9	23.13	Not Binding	3.28
Cost2048	35.28	Not Binding	12.30
Cost256	15.45	Not Binding	0.38
Cost512	20.50	Not Binding	0.90
Price1024	53.90	Not Binding	11.07
Price1024	53.90	Not Binding	14.92
TotalQuantity	2,350,330	Not Binding	1,370.39
Price1024.3	35.55	Not Binding	0.20
Price1024.9	43.28	Not Binding	5.72
Price256	25.93	Not Binding	3.28
Price256	25.93	Not Binding	8.41
Price512	35.06	Not Binding	9.86
Price512	35.06	Not Binding	8.11
Price1024.6	39.32	Not Binding	0.02
TotalQuantity	2,350,330	Not Binding	1,402,370.39

Comparison of prices as of October 2006 and proposed prices (Figure 21) shows that price changes for the packages available in the model output correspond to:

- 23% increase in the 1024 Kbps with 3 GB offer,
- 61% decrease in the 1024 Kbps offer,
- 66% decrease in the 2048 Kbps offer

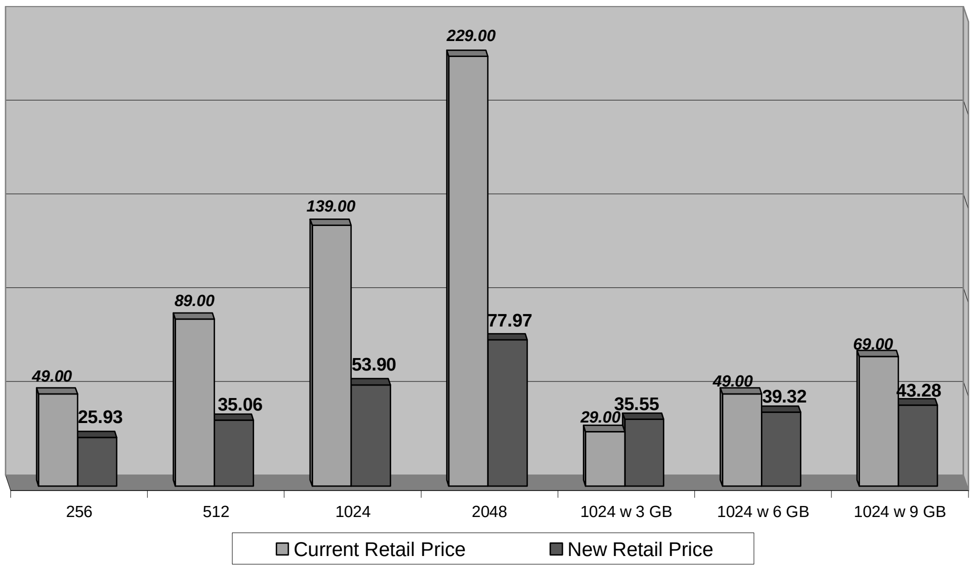

Figure 21: Current Prices vs. Model Output

Comparison of Tables 7 and 8 shows that monthly profit has risen from 11 million TL to 18.5 million TL according to the migration algorithm used in the optimization model. Because the demand is elastic and migration model assumed that customers do not respond to increases up to a certain amount (assumed as 20% in the migration model), increases in profits with lower prices is an intuitive result.

The model has ended up with three packages as opposed to the seven current packages as shown in Table 9.

Table 9: Current Customer Figure vs. Model Output

Offer Type	Current Figure (as of October 2006)	Model Output
256/64 Kbps	317,096	-
512/128 Kbps	62,640	-
1024/256 Kbps	34,061	394,615
2048/512 Kbps	34,514	226,281
1024 Kbps /w 3 GB download	1,827,722	1,729,434
1024 Kbps /w 6 GB download	71,619	-
1024 Kbps /w 9 GB download	4,048	-

According to Table 8, all constraints are found to be non-binding, which shows that the shadow prices of the constraints are zero. That is the firm is free to choose prices in the range of the slack values without any change in the value of the objective function. Indeed Lagrange multipliers, which correspond to the shadow prices, equal to zero for all of the constraints except the constraint defining the lower limit of customer number (Table 10).

Table 10: Sensitivity Report

Microsoft Excel 11.0 Sensitivity Report

Adjustable Cells

Cell	Name	Final Value	Reduced Gradient
D15	Price256K	26.65	-
D16	Price512K	35.63	-
D17	Price1024K	53.90	-
D18	Price2048K	77.70	-
D19	Price1024K.3G	35.55	-
D20	Price1024K.6G	39.33	-
D21	Price1024K.9G	43.27	-

Constraints

Cell	Name	Final Value	Lagrange Multiplier
D29	Cost1024	29.31	-
D31	Cost1024.3	21.17	-
D32	Cost1024.6	22.19	-
D33	Cost1024.9	23.13	-
D30	Cost2048	35.27	-
D27	Cost256	15.45	-
D28	Cost512	20.50	-
B29	Price1024	53.90	-
B29	Price1024	53.90	-
B35	TotalQuantity	2,350,349	- 18
B31	Price1024.3	35.55	-
B33	Price1024.9	43.27	-
B27	Price256	26.65	-
B27	Price256	26.65	-
B28	Price512	35.63	-
B28	Price512	35.63	-
B32	Price1024.6	39.33	-
B35	TotalQuantity	2,350,349	-

Table 11 illustrates the limits report generated by Solver. Limits report is obtained by running the optimization with a decision variable, while keeping other decision variables constant at their optimum values. According to Table 11, 1 TL change in the downward direction for 1024 Kbps 3 GB offer results in a loss of approximately 800,000 TL of monthly profit. Similarly for 1024 Kbps offer, 2.4 TL change in monthly price corresponds to a change of 365,000 TL of monthly profit in the same direction.

Table 11: Limits Report

Microsoft Excel 11.0 Limits Report

Cell	Target Name	Value
B39	NetProfit	18,561,947

Cell	Adjustable Name	Value	Lower Limit	Target Result	Upper Limit	Target Result
D15	Price256K	25.93	25.31	18,561,946.58	29.21	18,561,946.58
D16	Price512K	35.06	33.59	18,561,946.58	44.92	18,561,946.58
D17	Price1024K	53.90	47.72	17,089,762.97	50.10	17,454,625.20
D18	Price2048K	77.97	64.68	17,196,347.48	64.68	17,196,347.48
D19	Price1024K.3G	35.55	34.50	17,777,301.52	35.54	18,557,521.40
D20	Price1024K.6G	39.32	39.10	18,561,946.58	39.10	18,561,946.58
D21	Price1024K.9G	43.28	43.26	18,561,946.58	43.26	18,561,946.58

4.3.2 Discussion of the Results and ADSL Tariffs

Following observations and recommendations can be made according to the results of proposed pricing model:

- Despite the increase in the penetration rate, ADSL tariffs have evolved very little to reflect these changes. By change, it is not necessarily meant that the change in price levels, but rather the relation between the prices of different offers. A comparison with the European examples reveals that the range of prices is still very large (As of August 2006, 229 TL for 2 Mbps and 29 TL for 1 Mbps 3 GB offers). This reveals the case of cross-subsidization between higher speed and lower speed options.

- Since most of the new ADSL customers are subscribing to the 1024 Kbps 3 GB package, this tariff structure is not believed to be a sustainable one. It is necessary for Türk Telekom to increase its average revenue per user (ARPU) by rearranging its tariffs and offering value added services.

- Transmission lines, which are the wholesale leased lines, form the main cost component. This is reflected in the current tariffs, where high transmission costs are reflected in the prices of higher speed access options (1 Mbps and 2 Mbps offers). While most of the Internet operations are still coordinated under Türk Telekom, Telecommunication Authority might speed up the process of local loop unbundling. In this case, operators having the ability to access the loop and the necessary infrastructure might offer differentiated services at competitive prices. As soon as TTNet starts offering Internet services in this manner (by leasing the transmission lines and other infrastructure), there is a need to review the costs of network components.

- Current tariffs do not reflect the cost of the local loop (copper wire access). This is a crucial cost component, which must be taken into account while pricing services using local loop access. Türk Telekom reports that its current fixed line monthly rental fee is below its cost, and this forms a deficit in the local access. Such deficit can be subsidized through call prices by an incumbent operator unless local loop unbundling is in operation. Thus Türk Telekom shall review its local loop and PSTN tariffs as well.

- Türk Telekom offers a single general type of service, which is used by both residential and business users. In countries like Ireland and United Kingdom, offers with higher contention ratios are available for residential users who utilize the network at lower levels. As transmission is a significant cost component, differentiation of services for residential users and business users can help Türk Telekom control its costs and attract low profile users at affordable prices and can charge higher rates to business users for premium services. In order to apply such price discrimination, different demand elasticity figures of residential and business users must be known.

CHAPTER 5

CONCLUSION

Despite the developments in technology, economics of networks has not shown a parallel development. Although there is continuous research in the field, hard nature of consumer behavior makes it very difficult to apply different and complex pricing schemes and rates.

The trade-off between the economic efficiency and technical efficiency is a problem to be solved in the best interest of stakeholders, namely the consumers and service providers. For markets highly sensitive to the pricing, even for incumbent operators the pricing issue becomes a problem not in the maturity, but in the development phase of a service.

This thesis addressed the issue of pricing from available data and tried to find a solution not necessarily optimal, but may guide the firm to better evaluate its tariff policies. Because tariffs are generally evaluated as a top management issue, one might conclude that businesses usually need some guiding figures rather than one time solution for tariff building.

The model results were highly dependent on the migration assumptions used and the underlying elasticity figure. Due to the lack of variables unexplored by the demand model, elasticity figure might include those unexplored variables' effects. The model had only one objective function, which is also a weakness as firms also try to expand their customer base together with increasing profits. Furthermore, as a result of the tables used in the model, which create discontinuous data, optimization tool is not robust and highly sensitive to the initial values.

As a future work, the proposed tariff model and its results shall be validated and further investigated through different optimization algorithms like evolutionary methods. Use of goal programming may also help to include the objective of enlargement of the customer base in addition to the profit maximization objective. Additionally, the constraints of the model should be explored in detail in order to increase the robustness of the model, as unbinding constraints affect the performance of such models adversely.

There is also a clear need to clarify the demographic data (income, education, etc.) in order to come up with more reliable elasticity figures to better estimate the demand for broadband services. Indeed there is little investigation of elasticities in developing countries and much of the study until now has focused mainly on the cases of developed countries. Furthermore, two-part tariff pricing schemes may also be evaluated, since they provide a basis for further price discrimination.

This thesis included a study of the Turkish ADSL market as a whole. A further investigation of the market through segments like business and residential customers can provide the elasticity figures needed for price discrimination. Then unexplored variables in the current model such as access speed may enter significantly to the model. This can help Türk Telekom to offer differentiated services to these markets.

Additionally, this thesis essentially offered only price as an input for the model. Other strategies such as service bundles and free hardware and their effect on consumers can be investigated through field study as well. Moreover, constraints such as the market conditions, competitive and regulatory issues shall be considered in detail as future evolution of technologies is a major factor of business decisions for Internet services. Although Türk Telekom's ADSL infrastructure is quite new compared to those of European countries, the replacement of the infrastructure with newer generation IP based networks might lead to changes in the form of revenues, where value added services will be more important compared to access revenues. Tariffs should reflect such changes where high speed offers are promoted in order to provide the value added services.

REFERENCES

Andersen Business Consulting (2002). *Study on the implementation of cost accounting methodologies and accounting separation by telecommunication operators with significant market power* (Prepared for the European Commission DG Information Society). Retrieved from *http://europa.eu.int/information_society/topics/telecoms/implementation/studies/costaccounting2002/costaccountingmethodologies.pdf on 04.09.2006*

Baker, R. (1998). "Genetic Algorithms in Search and Optimization". *Financial Engineering News July 1998.* Retrieved from http://www.fenews.com/fen5/ga.html on 15.11.2006

Begg, D., Fischer, S. & Dornbusch, R. (2001). *Makro İktisat* [Macroeconomics]. Alkım.

Boone, L.E. & Kurtz D.L. (1995). *Contemporary Marketing*. Dryden Press.

Bowerman, B.L., O'Connell, R.T. & Koehler, A.B. (2005). *Forecasting, Time Series and Regression: An Applied Approach*. Thomson Brooks/Cole.

Burton, M. & Hicks, M.J. (July 2005). *The Residential and Commercial Benefits of Rural Broadband: Evidence From Central Appalachia*. Center for Business and Economic Research Marshall University. Retrieved from http://www.marshall.edu./cber/research/broadband/Final%20Rural%20Broadband%20July%202005.pdf on 14.11.2006

Carlton, D.W. & Perloff, J.M. (2000). *Modern Industrial Organization*. Addison Wesley.

Cave, M. (2003). *Remedies for Broadband Services, Study for the Commission.* Retrieved from European Union's web site http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/studies_ext_consult/economic_expert_group/broadband%20_cave.pdf on 26.06.2006

Cerf, V.G. (2004). On the evolution of Internet technologies. *Proceedings of the IEEE Volume 92, Issue 9, Sep 2004* pp: 1360 – 1370. Retrieved from http://ieeexplore.ieee.org/iel5/5/29301/01323283.pdf on 15.12.2006

Cerno, L. & Amaral, T.P. (2005). *Demand for Internet Access and Use in Spain*. Paper retrieved from http://www.ucm.es/BUCM/cee/icae/doc/0506.pdf on 14.11.2006

Coffman, K. G. & Odlyzko, A. (2002). Internet growth: Is there a "Moore's Law" for data traffic?, In J. Abello, P. M. Pardalos, and M. G. C. Resende (Eds.), *Handbook of Massive Data Sets*: pp. 47-93. Kluwer. Retrieved from http://www.dtc.umn.edu/~odlyzko/doc/internet.moore.pdf on 26.06.2006

Commission of the European Communities (15.07.2005). *Digital Divide Forum Report: Broadband Access and Public Support in Under-Served Areas.* Retrieved from http://europa.eu.int/information_society/eeurope/i2010/docs/implementation/ddf_report_final.pdf on 03.09.2006

Commission of the European Communities (20.02.2006). *European Electronic Communications Regulation and Market 2005 (11th Report).* Retrieved from http://europa.eu.int/information_society/policy/ecomm/info_centre/documentation/communic_reports/index_en.htm on 10.05.2006

Courcoubetis, C. & Weber, R. (2003). *Pricing Communication Networks: Economics, Technology and Modeling.* Wiley.

Crandall, R.W. (2003). Broadband Communications. Preliminary Draft of a chapter in Martin E. Cave, Sumit K. Majumdar & Ingo Vogelsang (Eds.), *The Handbook of Telecommunications Economics* Vol. 2, North Holland 2003. Retrieved from http://www.brookings.edu/views/papers/crandall/200305.pdf on 14.11.2006

Crowcroft, J., Hand, S., Mortier, R., Roscoe, T., Warfield, A. (2003). *QoS's downfall: At the bottom, or not at all!,* ACM SIGCOMM 2003 Workshops August 25&27, 2003. Karlsruhe.

Dippon, C.M. (2001). *Competitive Pricing Methodologies for Wholesale Broadband Services.* National Economic Research Associates.

Dittberner Associates (2006). *Broadband Access Quarterly Shipment Report* (press release August 16, 2006). Retrieved from http://www.dittberner/com/news/press_release.php?id=57&PHPSESSID=b470044 on 15.11.2006

DSL Forum (2001). *Protocols at the U Interface for Accessing Data Networks using ATM/DSL.* DSL Forum Technical Report TR-043. Retrieved from http://www.dslforum.org/aboutdsl/Technical_Reports/TR-043.doc on 14.11.2006

DSL Forum (2004). *Broadband Remote Access Server (BRAS) Requirements Document*. DSL Forum Technical Report TR-092. Retrieved from http://www.dslforum.org/aboutdsl/Technical_Reports/TR-092.doc on 14.11.2006

Ekergil, V. (2006). *Telekomünikasyon Sektöründe Maliyetleme ve Maliyete Dayalı Fiyatlandırma Yaklaşımları* [Costing and Cost Based Pricing Approaches in Telecommunications Sector]. Anadolu Üniversitesi İktisadi ve İdari Bilimler Fakültesi Yayınları.

European Regulators Group (2005). *ERG (03) Rev2 Revised Common Position on wholesale bitstream access* – Adopted on 2nd April 2004 and amended on 25th May 2005. Retrieved from http://erg.eu.int/doc/whatsnew/erg_03_33rev2_bitstream_access_final_plus_cable_adopted.pdf on 26.06.2006

Evans, J.R. (2007). *Statistics, Data Analysis & Decision Modeling*. Pearson Prentice Hall.

Fader, P.S. & Hardie, B.G.S. (2005). The value of simple models in new product forecasting and customer-base analysis. *Appl. Stochastic Models Bus. Ind., 2005; 21:* pp. 461-473, Retrieved from http://marketing.wharton.upenn.edu/ideas/pdf/Fader/PapersNew/Simple%20Models%20ASMBI%202005.pdf on 07.03.2006

Falkner, M., Devetsikiotis, M. & Lambaradis, I. (2000). *An Overview of Pricing Concepts for Broadband IP Networks. IEEE Communications Surveys, 2nd Quarter 2000*: pp. 2-13. Retrieved from http://www-rp.lip6.fr/maitrise/articles/Falkner.pdf on 03.09.2006

Fuss, M. & Waverman, L. (2002). Econometric Cost Functions. In M.E. Cave, S.K. Majumdar & I. Vogelsang (Eds.), *Handbook of Telecommunications Economics Volume 1:* pp. 143-177. Elsevier.

Gibbens, R.J. & F. P. Kelly (2000). Resource Pricing and the Evolution of Congestion Control, *Automatica, vol. 35:* pp. 1969-1985

Goolsbee, A. (2002). Subsidies, the Value of Broadband, and the Importance of Fixed Costs. In R.W. Crandall & J.H. Alleman (Eds.), *Broadband "Should We Regulate High-Speed Internet Access?"*, AEI-Brookings Joint Center for Regulatory Studies. Retrieved from http://www.aei-brookings.org/admin/authorpdfs/page.php?id=219 on 26.10.2006

Humphreys, P. & Simpson, S. (2005). *Globalization, Convergence and European Telecommunications Regulation*. Edward Elgar Publishing.

Intven, H. [ed.] (2000). *Telecommunication Regulation Handbook: Appendices*. The Worldbank. Retrieved from http://www.infodev.org/files/1087_file_appendix.pdf#search=%22telecommunication%20fdc%20lric%20cost%20models%22 on 31.08.2006

ITU (2003). *Denmark Mini-Case Study 2003: Beyond Disputes and Towards Consensus Building.* ITU. Retrieved from http://www.itu.int/ITU-D/treg/Case_Studies/Disp-Resolution/Denmark.pdf#search=%22denmark%20fixed%20interconnection%20benchmark%201997%22 on 05.09.2006

Kaplan, Y. (2000). *Veri Haberleşmesi Kavramları* [Data Communications Concepts]. Papatya Yayıncılık.

Keat, P.G. & Young P.K.Y. (1996). *Managerial Economics: Economic Tools for Today's Decision Makers*. Prentice Hall.

Kurose, J.F. & Ross, K.W. (2003). *Computer Networking: A Top-Down Approach Featuring the Internet*. Addison-Wesley.

Levenbach, H. & Cleary, J.P. (2006). *Forecasting "Practice and Process for Demand Management".* Thomson Brooks/Cole.

Li, T., Iraqi, Y. & Boutaba, R. (2004). Pricing and Admission Control for QoS Enabled Internet, *The International Journal of Computer and Telecommunications Networking, Volume 46, Issue 1*: pp. 87-110. Elsevier.

Marn, M.V., Roegner, E.V. & Zawada, C.G. (2003). The power of pricing. *McKinsey Quarterly 2003 Number 1*. McKinsey & Company.

Marsan, M.A., Bianco, A., Calderini, M.,Cambini, C. & Meo, M. (2001). *Trade-offs Between Tariffs and QoS in Mobile Telephony Networks: an Integrated Design Approach*, Sixth IEEE Symposium on Computers and Communications (ISCC'01). Retrieved from http://www.tlc-networks.polito.it/~bianco/Papers_pdf/2001/iscc.pdf on 16.11.2004

Marshall, A. (1982). *Principles of Economics.* Porcupine Predd.

McClave, J.T. & Benson, P.G. (1991). *Statistics for Business and Economics.* Dellen Macmillan.

Meigs, R., Williams, J.R., Haka, S.F. & Bettner, M.S. (1999). *Accounting: The Basis for Business Decisions.* McGraw-Hill.

Miles, J. & Shevlin, M. (2001). *Applying Regression & Correlation*. SAGE.

Minoli, D. (2003). *Telecommunications Technology Handbook.* Artech House.

Monroe, K.B. (1990). *Pricing: Making Profitable Decisions*. McGraw-Hill.

Montgomery, S. L. (1988). *Profitable Pricing Strategies*. McGraw-Hill.

Odlyzko, A. (July 7, 1998). *The economics of Internet: Utility, utilization, pricing, and Quality of Service*. Retrieved from author's web site http://www.dtc.umn.edu/~odlyzko/doc/internet.economics.pdf on 26.06.2006

Odlyzko, A. (June 16, 2000). *History of telecommunications and its implications for the Internet.* Retrieved from author's web site http://www.dtc.umn.edu/~odlyzko/doc/history.communications0.pdf on 26.06.2006

Odlyzko, A. (2001a). Internet growth: Myth and reality, use and abuse, *J. Computer Resource Management, issue 102, Spring:* pp. 23-27. Retrieved from author's web site http://www.dtc.umn.edu/~odlyzko/doc/internet.growth.myth2.pdf on 26.06.2006

Odlyzko, A. (2001b). Internet pricing and the history of communications. *Computer Networks 36:* pp. 493-517. Retrieved from author's web site http://www.dtc.umn.edu/~odlyzko/doc/history.communications1b.pdf on 26.06.2006

OECD (2004). *Access Pricing in Telecommunications*. (2004). Paris: OECD.

OECD (2005). *Broadband Statistics, December 2005*. Retrieved from www.oecd.org/sti/ict/broadband on 15.11.2006

Ofcom (2004). *Wholesale Broadband Access Market*. Retrieved from http://www.ofcom.org.uk/consult/condocs/wbamp/wholesalebroadbandreview/broadbandaccessreview.pdf on 29.11.2006

Ofcom (2005). *Final statements on the Strategic Review of Telecommunications, and undertakings in lieu of a reference under the Enterprise Act 2002.* Retrieved from http://www.ofcom.org.uk/consult/condocs/statement_tsr/statement.pdf on 03.09.2006

Ofcom (2006). *The Telecommunications Market 2006*. Retrieved from http://www.ofcom.org.uk/research/cm/cm06/telec.pdf on 03.09.2006

Phlips, L. (1983). *The Economics of Price Discrimination*, Cambridge University Press.

Rappoport, P., Kriedel, D.J., Taylor, L.D. & Alleman, J. (2003). *Residential Demand for Access to Internet (working paper).* Retrieved from http://www.colorado.edu/engineering/alleman/print_files/Forecasting_the_Demand_for_Internet_Services.PDF on 14.11.2006

Ross, S.A., Westerfield, R.W. & Jaffe, J. (1999). *Corporate Finance*. McGraw-Hill.

Shin, S. & Weiss, M.B.H. (2002). Simulation Analysis of QoS Enabled Internet Pricing Strategies: Flat Rate vs. Two-Part Tariff. *Proceedings of the 36th Hawaii International Conference on System Sciences (HICSS'03).* IEEE

Star, T., Sorbara, M., Cioffi, J.M. & Silverman, P.J. (2003). *DSL Advances*. Prentice Hall.

Stiller, B., Reichl, P. & Leinen, S. (2001). A Practical Review of Pricing and Cost Recovery for Internet Services, *Netnomics Vol. 3, No.1:* pp. 149-171. Retrieved from http://www.tik.ee.ethz.ch/~cati/paper/netnomics00.pdf on 26.06.2004

Vogelsang, I (2002). *The German Telecommunications Reform – Where did it Come from,Where is it, and Where is it Going?*. Presentation at Verein für Socialpolitik Annual Meetings Innsbruck, September 19, 2002. Retrieved from http://www.bu.edu/econ/workingpapers/papers/Ingo%20Vogelsang/VfS_IV.pdf#search=%22germany%20regtp%20interconnection%20benchmark%20%22 on 05.09.2006

Wairua Consulting (2006). *Comparison of OECD Broadband Markets A comparison of cost and performance data for business and residential broadband products in 26 OECD countries.* Report for prepared for InternetNZ. Retrieved from http://www.internetnz.net.nz/pubs/other/2006-05-29-oecd-broadband-markets on 13.11.2006

Walrand, J. & Varaiya, P. (2000). *High Performance Communication Networks*. Morgan Kaufmann.

Winston, W.L. (2000). *Financial Models Using Simulation and Optimization*. Palisade Corporation.

Winston, W.L. (2004). *Operations Research Applications and Algorithms*. Thomson Brooks/Cole.

APPENDICES

APPENDIX A: OECD BROADBAND KEY STATISTICS[23]

Table 12: Broadband Subscribers per 100 Inhabitants, 2001-2005

	2001	2002	2003	2004	2005
Australia	0.9	1.8	3.5	7.7	13.8
Austria	3.6	5.6	7.6	10.1	14.1
Belgium	4.4	8.7	11.7	15.5	18.3
Canada	8.9	12.1	15.1	17.6	21.0
Czech Republic	0.1	0.2	0.5	2.5	6.4
Denmark	4.4	8.2	13.0	19.0	25.0
Finland	1.3	5.5	9.5	14.9	22.5
France	1.0	2.8	5.9	10.5	15.2
Germany	2.3	4.1	5.6	8.4	13.0
Greece	0	0	0.1	0.4	1.4
Hungary	0.3	0.6	2.0	3.6	6.3
Iceland	3.7	8.4	14.3	18.2	26.7
Ireland	0	0.3	0.8	3.3	6.7
Italy	0.7	1.7	4.1	8.1	11.9
Japan	2.2	6.1	10.7	15.0	17.6
Korea	17.2	21.8	24.2	24.8	25.4
Luxembourg	0.3	1.5	3.5	9.8	14.9
Mexico	0.1	0.3	0.4	0.9	2.2
Netherlands	3.8	7.0	11.8	19.0	25.3
New Zealand	0.7	1.6	2.6	4.7	8.1
Norway	1.9	4.2	8.0	14.8	21.9
Poland	0.1	0.3	0.8	2.1	2.4
Portugal	1.0	2.5	4.8	8.2	11.5
Slovak Republic	0	0	0.3	1.0	2.5

[23] The data is reproduced from OECD Broadband Statistics, December 2005, retrieved from www.oecd.org/sti/ict/broadband on 15.11.2006

Table 12 (cont.): Broadband Subscribers per 100 Inhabitants, 2001-2005

Spain	1.2	3.0	5.4	8.1	11.7
Sweden	5.4	8.1	10.7	14.5	20.3
Switzerland	2.0	5.6	10.1	17.5	23.1
Turkey	0	0	0.3	0.7	2.1
United Kingdom	0.6	2.3	5.4	10.5	15.9
United States	4.5	6.9	9.7	12.9	16.8
OECD	**2.9**	**4.9**	**7.3**	**10.2**	**13.6**
EU15	**1.6**	**3.4**	**5.9**	**9.7**	**14.2**

Table 13: Broadband Subscribers per 100 Inhabitants, by Technology, June 2006

	DSL	Cable	Other	Total	Rank	Total Subscribers
Denmark	17.4	9.0	2.8	29.3	1	1,590,539
Netherlands	17.2	11.1	0.5	28.8	2	4,705,829
Iceland	26.5	0.0	0.7	27.3	3	80,672
Korea	13.2	8.8	4.5	26.4	4	12,770,911
Switzerland	16.9	9.0	0.4	26.2	5	1,945,358
Finland	21.7	3.1	0.2	25.0	6	1,309,800
Norway	20.4	3.8	0.4	24.6	7	1,137,697
Sweden	14.4	4.3	4.0	22.7	8	2,046,222
Canada	10.8	11.5	0.1	22.4	9	7,161,872
United Kingdom	14.6	4.9	0.0	19.4	10	11,622,929
Belgium	11.9	7.4	0.0	19.3	11	2,025,112
United States	8.0	9.8	1.4	19.2	12	56,502,351
Japan	11.3	2.7	4.9	19.0	13	24,217,012
Luxembourg	16.0	1.9	0.0	17.9	14	81,303
Austria	11.2	6.3	0.2	17.7	15	1,460,000
France	16.7	1.0	0.0	17.7	16	11,105,000
Australia	13.9	2.9	0.6	17.4	17	3,518,100
Germany	14.7	0.3	0.1	15.1	18	12,444,600
Spain	10.5	3.1	0.1	13.6	19	5,917,082
Italy	12.6	0.0	0.6	13.2	20	7,697,249
Portugal	7.9	5.0	0.0	12.9	21	1,355,602
New Zealand	10.7	0.5	0.6	11.7	22	479,000
Czech Republic	3.9	2.0	3.5	9.4	23	962,000
Ireland	6.8	1.0	1.4	9.2	24	372,300
Hungary	4.8	2.9	0.1	7.8	25	791,555
Poland	3.9	1.3	0.1	5.3	26	2,032,700
Turkey	2.9	0.0	0.0	3.0	27	2,128,600
Slovak Republic	2.2	0.5	0.2	2.9	28	155,659
Mexico	2.1	0.7	0.0	2.8	29	2,950,988
Greece	2.7	0.0	0.0	2.7	30	298,222
OECD	**9.7**	**4.6**	**1.2**	**15.5**		**180,866,265**

APPENDIX B: TÜRK TELEKOM'S ADSL AND DIAL UP SUBSCRIBER BASE DEVELOPMENT IN 2004 AND 2005 [24]

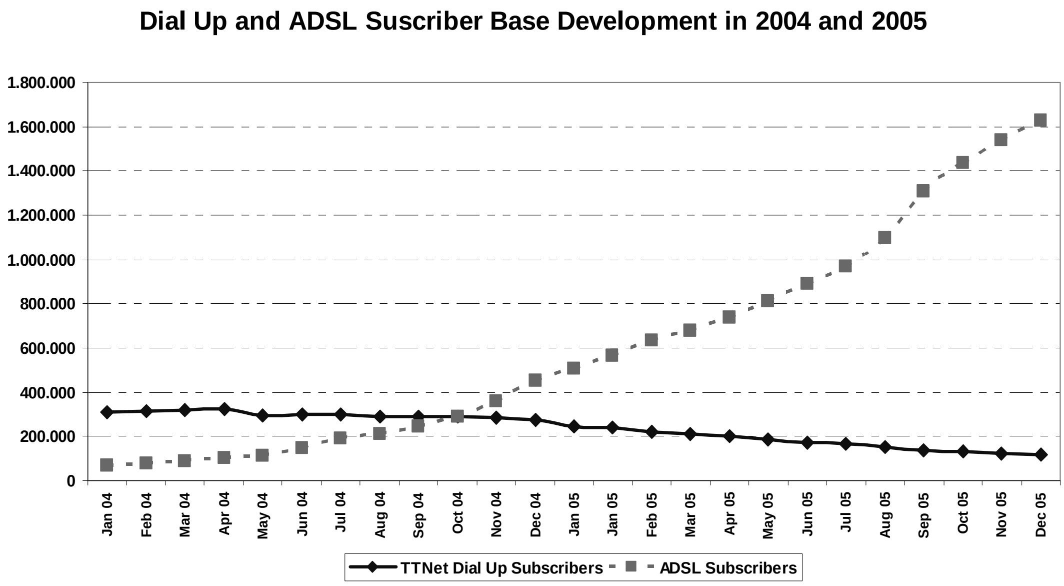

Figure 22: Dial Up and ADSL Subscriber Base Development in 2004 and 2005

[24] Source: Türk Telekom unofficial internal data

APPENDIX C: ANALYSIS OF THE DEMAND MODEL

This appendix includes the regression output of the demand function produced by the Minitab software and the analysis of the regression assumptions.

Minitab Output

Regression Analysis: Ln(Quantity) versus Ln (Price), Limit, Month

```
The regression equation is
Ln(Quantity) = 17.0 - 2.09 Ln (Price) + 1.88 Limit + 0.0942 Month


Predictor        Coef   SE Coef       T      P  VIF
Constant      16.9769    0.3404   49.87  0.000
Ln (Price)   -2.09315   0.07823  -26.76  0.000  1.6
Limit          1.8768    0.1625   11.55  0.000  1.7
Month        0.094213  0.007925   11.89  0.000  1.1


S = 0.547782   R-Sq = 89.7%   R-Sq(adj) = 89.4%

PRESS = 37.0444   R-Sq(pred) = 88.70%


Analysis of Variance

Source           DF       SS      MS       F      P
Regression        3  293.810  97.937  326.38  0.000
Residual Error  113   33.907   0.300
Total           116  327.717


Source      DF   Seq SS
Ln (Price)   1  228.869
Limit        1   22.535
Month        1   42.406


Obs  Ln (Price)  Ln(Quantity)      Fit  SE Fit  Residual  St Resid
  1        3.89       10.1600  10.8056  0.1266   -0.6456     -1.21
  2        4.23        9.8300  10.0939  0.1124   -0.2639     -0.49
  3        4.69        8.8900   9.1310  0.1014   -0.2410     -0.45
  4        5.52        7.3400   7.3937  0.1123   -0.0537     -0.10
  5        6.14        6.4800   6.0960  0.1409    0.3840      0.73
  6        3.89       10.3700  10.8998  0.1213   -0.5298     -0.99
  7        4.23       10.0400  10.1881  0.1065   -0.1481     -0.28
  8        4.69        9.1000   9.2253  0.0950   -0.1253     -0.23
  9        5.52        7.5500   7.4879  0.1068    0.0621      0.12
```

10	6.14	6.6800	6.1902	0.1367	0.4898	0.92
11	3.89	10.4900	10.9940	0.1164	-0.5040	-0.94
12	4.23	10.1500	10.2823	0.1009	-0.1323	-0.25
13	4.69	9.2200	9.3195	0.0889	-0.0995	-0.18
14	5.52	7.6600	7.5821	0.1016	0.0779	0.14
15	6.14	6.8000	6.2844	0.1328	0.5156	0.97
16	3.89	10.6200	11.0882	0.1118	-0.4682	-0.87
17	4.23	10.2800	10.3765	0.0957	-0.0965	-0.18
18	4.69	9.3500	9.4137	0.0830	-0.0637	-0.12
19	5.52	7.7900	7.6764	0.0967	0.1136	0.21
20	6.14	6.9300	6.3786	0.1292	0.5514	1.04
21	3.89	10.7600	11.1824	0.1076	-0.4224	-0.79
22	4.23	10.4200	10.4707	0.0908	-0.0507	-0.09
23	4.69	9.4900	9.5079	0.0775	-0.0179	-0.03
24	5.52	7.9400	7.7706	0.0923	0.1694	0.31
25	6.14	7.0700	6.4728	0.1261	0.5972	1.12
26	3.89	10.8800	11.2766	0.1038	-0.3966	-0.74
27	4.23	10.5500	10.5650	0.0864	-0.0150	-0.03
28	4.69	9.6100	9.6021	0.0725	0.0079	0.01
29	5.52	8.0600	7.8648	0.0884	0.1952	0.36
30	6.14	7.2000	6.5670	0.1234	0.6330	1.19
31	3.89	11.1300	11.3708	0.1005	-0.2408	-0.45
32	4.23	10.8000	10.6592	0.0825	0.1408	0.26
33	4.69	9.8600	9.6963	0.0680	0.1637	0.30
34	5.52	8.3100	7.9590	0.0850	0.3510	0.65
35	6.14	7.4400	6.6612	0.1211	0.7788	1.46
36	3.89	11.3900	11.4651	0.0977	-0.0751	-0.14
37	4.23	11.0500	10.7534	0.0793	0.2966	0.55
38	4.69	10.1200	9.7905	0.0642	0.3295	0.61
39	5.19	8.5600	8.7440	0.0686	-0.1840	-0.34
40	5.63	7.7000	7.8230	0.0880	-0.1230	-0.23
41	3.89	11.4900	11.5593	0.0955	-0.0693	-0.13
42	4.23	11.1600	10.8476	0.0767	0.3124	0.58
43	4.69	10.2200	9.8847	0.0612	0.3353	0.62
44	5.19	8.6700	8.8382	0.0660	-0.1682	-0.31
45	5.63	7.8000	7.9172	0.0862	-0.1172	-0.22
46	3.89	12.4600	11.8419	0.0928	0.6181	1.14
47	3.37	10.5400	11.0535	0.1220	-0.5135	-0.96
48	4.60	10.5000	10.3558	0.0597	0.1442	0.26
49	3.89	8.1400	9.9651	0.1214	-1.8251	-3.42R
50	5.13	9.0200	9.2464	0.0617	-0.2264	-0.42
51	5.59	8.2400	8.2835	0.0826	-0.0435	-0.08
52	3.89	12.5700	11.9361	0.0932	0.6339	1.17
53	3.37	11.4200	11.1478	0.1194	0.2722	0.51
54	4.60	10.5400	10.4500	0.0606	0.0900	0.17
55	3.89	9.0200	10.0593	0.1188	-1.0393	-1.94
56	5.13	9.1700	9.3406	0.0629	-0.1706	-0.31
57	5.59	8.4400	8.3778	0.0836	0.0622	0.11
58	3.89	12.5800	12.0303	0.0943	0.5497	1.02
59	3.37	11.8200	11.2420	0.1172	0.5780	1.08
60	4.60	10.6000	10.5442	0.0626	0.0558	0.10
61	3.89	9.1900	10.1535	0.1168	-0.9635	-1.80
62	5.13	9.2400	9.4348	0.0651	-0.1948	-0.36
63	5.59	8.5200	8.4720	0.0854	0.0480	0.09
64	3.89	12.5800	12.1245	0.0961	0.4555	0.84
65	3.37	12.1400	11.3362	0.1155	0.8038	1.50
66	4.60	10.6900	10.6384	0.0655	0.0516	0.09
67	3.89	9.3000	10.2477	0.1152	-0.9477	-1.77
68	5.13	9.3300	9.5290	0.0681	-0.1990	-0.37
69	5.59	8.6000	8.5662	0.0878	0.0338	0.06
70	3.89	12.6000	12.2188	0.0984	0.3812	0.71
71	3.37	12.4000	11.4304	0.1144	0.9696	1.81
72	4.60	10.7500	10.7326	0.0692	0.0174	0.03
73	3.89	9.4700	10.3420	0.1142	-0.8720	-1.63

74	5.13	9.4200	9.6232	0.0718	-0.2032	-0.37
75	5.59	8.8200	8.6604	0.0909	0.1596	0.30
76	3.89	12.6000	12.3130	0.1013	0.2870	0.53
77	3.37	12.5500	11.5246	0.1138	1.0254	1.91
78	4.60	9.5700	10.8268	0.0736	-1.2568	-2.32R
79	3.89	10.7800	10.4362	0.1137	0.3438	0.64
80	5.13	9.4900	9.7175	0.0762	-0.2275	-0.42
81	5.59	8.8900	8.7546	0.0946	0.1354	0.25
82	3.89	12.6400	12.4072	0.1048	0.2328	0.43
83	3.37	12.6900	11.6188	0.1137	1.0712	2.00
84	4.60	10.8200	10.9210	0.0785	-0.1010	-0.19
85	3.89	9.6700	10.5304	0.1138	-0.8604	-1.61
86	5.13	9.5600	9.8117	0.0811	-0.2517	-0.46
87	5.59	8.9700	8.8488	0.0987	0.1212	0.22
88	3.89	12.6700	12.5014	0.1087	0.1686	0.31
89	3.37	12.8400	11.7130	0.1142	1.1270	2.10R
90	4.60	10.8700	11.0153	0.0838	-0.1453	-0.27
91	3.89	9.7800	10.6246	0.1144	-0.8446	-1.58
92	5.13	9.6300	9.9059	0.0865	-0.2759	-0.51
93	5.59	9.0600	8.9430	0.1033	0.1170	0.22
94	3.89	12.7000	12.5956	0.1130	0.1044	0.19
95	3.37	13.0000	11.8073	0.1152	1.1927	2.23R
96	4.60	10.9100	11.1095	0.0896	-0.1995	-0.37
97	3.89	9.8500	10.7188	0.1155	-0.8688	-1.62
98	5.13	9.6800	10.0001	0.0923	-0.3201	-0.59
99	5.59	9.1100	9.0372	0.1083	0.0728	0.14
100	3.89	12.7300	12.6898	0.1177	0.0402	0.08
101	3.37	13.1400	11.9015	0.1168	1.2385	2.31R
102	4.60	10.9400	11.2037	0.0957	-0.2637	-0.49
103	3.89	9.9200	10.8130	0.1172	-0.8930	-1.67
104	5.13	9.7300	10.0943	0.0983	-0.3643	-0.68
105	5.59	9.1500	9.1315	0.1136	0.0185	0.03
106	3.89	12.7700	12.7840	0.1227	-0.0140	-0.03
107	3.37	13.3300	11.9957	0.1188	1.3343	2.50R
108	4.60	10.9900	11.2979	0.1020	-0.3079	-0.57
109	3.89	10.0100	10.9072	0.1194	-0.8972	-1.68
110	5.13	9.8700	10.1885	0.1046	-0.3185	-0.59
111	5.59	9.2900	9.2257	0.1192	0.0643	0.12
112	3.89	12.8400	12.8782	0.1281	-0.0382	-0.07
113	3.37	13.5800	12.0899	0.1214	1.4901	2.79R
114	4.60	11.0400	11.3921	0.1085	-0.3521	-0.66
115	3.89	10.0800	11.0015	0.1220	-0.9215	-1.73
116	5.13	9.8700	10.2827	0.1111	-0.4127	-0.77
117	5.59	9.2900	9.3199	0.1250	-0.0299	-0.06

R denotes an observation with a large standardized residual.

Durbin-Watson statistic = 1.89491

Correlations: Ln(Quantity), Ln (Price), Limit, Month

	Ln(Quantity)	Ln (Price)	Limit
Ln (Price)	-0.836		
	0.000		
Limit	-0.290	0.598	
	0.002	0.000	
Month	0.474	-0.247	-0.357
	0.000	0.007	0.000

```
Cell Contents: Pearson correlation
               P-Value
```

Analysis of the Demand Model

Adjusted R-square and Overall F-test, which show the model's functioning as a whole. F-score for the model is 326.8 and p value is 0. Assuming

H_0: all of the parameters equal to 0.
H_a: At least, one of the parameters does not equal to 0.

As $F_{model} > F_{[0,05]}$

- 326.8 > 2.68 (having k=3 and (117-(3+1))= 113 degrees of freedom)
- P-value < 0.05

It can be inferred that the regression model is significant at level of 0.05.

As data is based on a term of 2 year values, it may be inferred that *independence assumption* may not hold true. According to Figure 23, residuals follow a predictable trend.

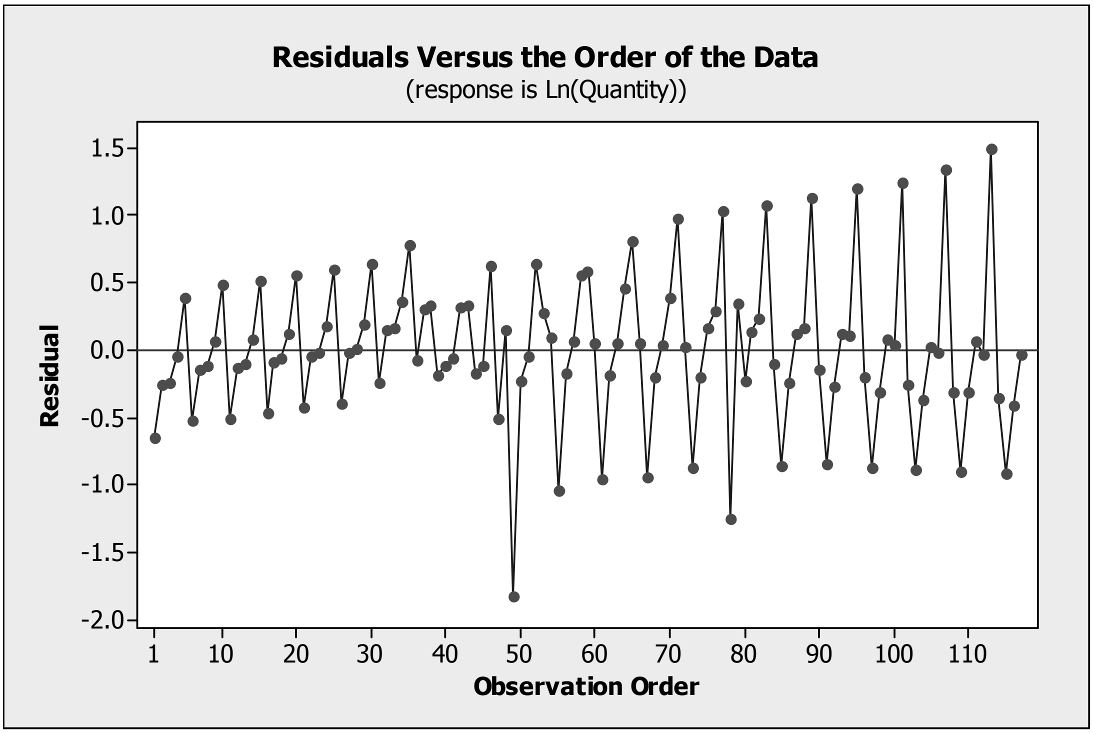

Figure 23: Residuals vs. the Order of the Data

Durbin Statistic is used to test autocorrelation. According to the Minitab output, Durbin-Watson statistics "*d*" is 1.84981. Assuming

H_0: The error terms are autocorrelated.

H_a: The error terms are positively autocorrelated.

As $d > d_{U,\alpha=0,05}$

- 1.84891 > 1.69

H_0 is not rejected and it can be the error terms are not autocorrelated at a significance level of 0.05. As a result independence assumption holds for the model.

Normality assumption holds according to Figure 24, where the distribution of the error terms approximates to the normal distribution (bell shaped and symmetric around 0).

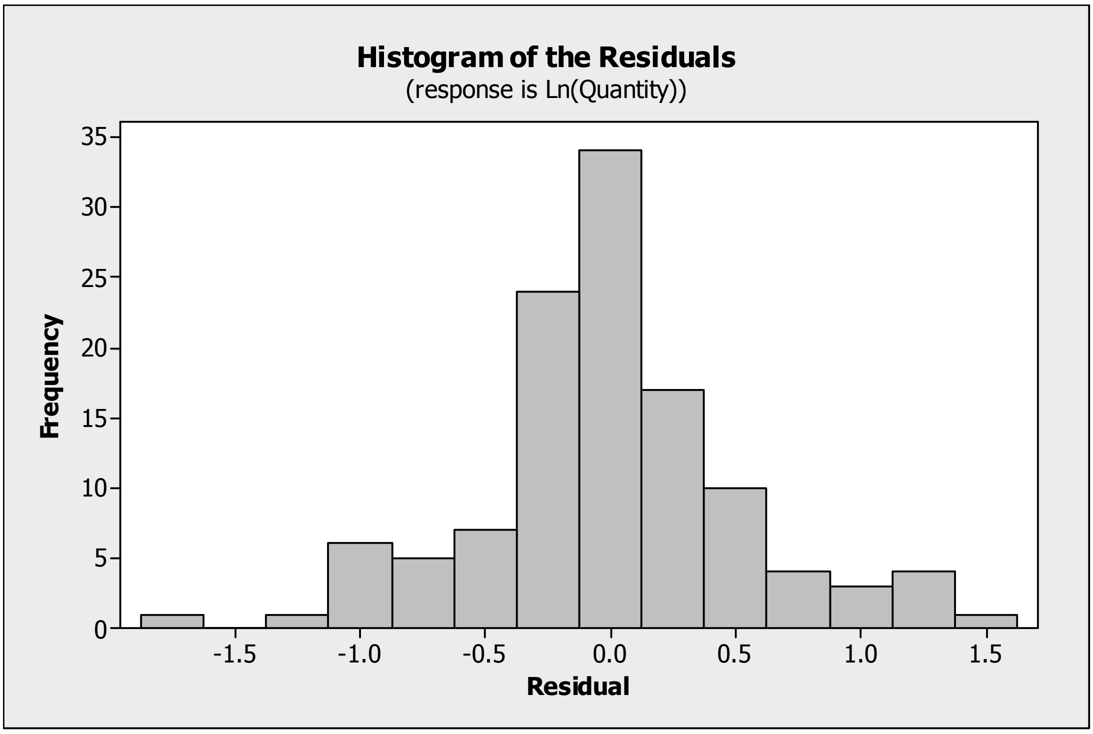

Figure 24: Histogram of the Residuals

Normal plot of the residuals approximate to a straight line, although there are outliers (Figure 25).

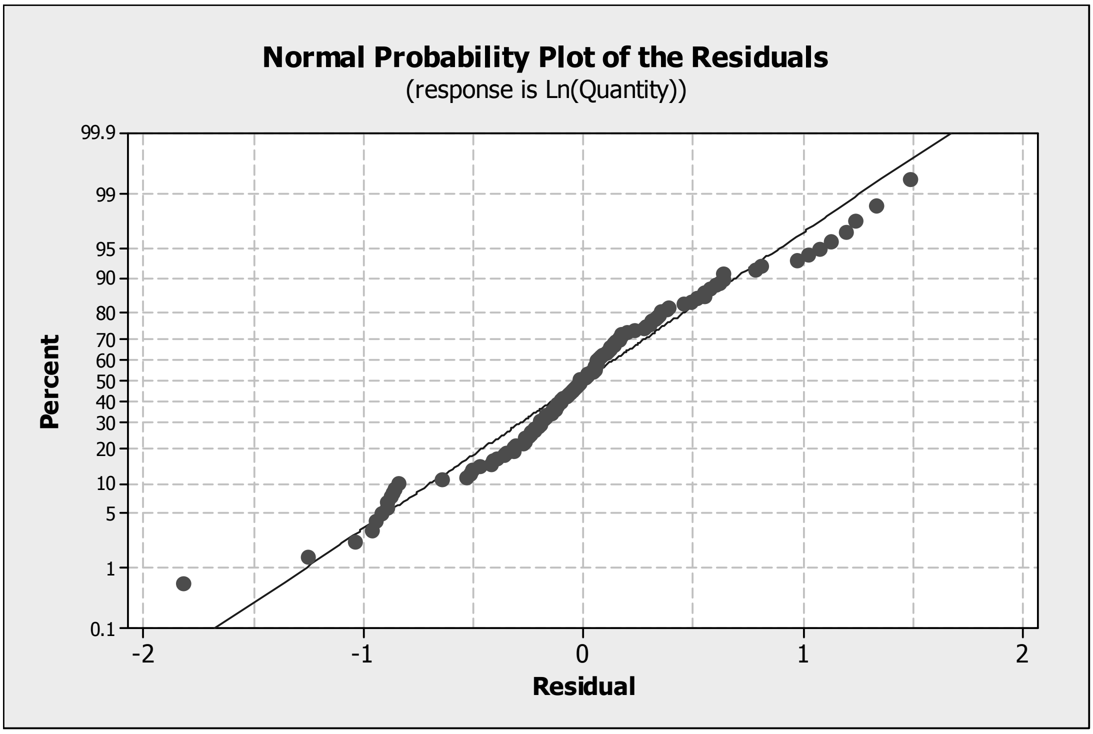

Figure 25: Normal Probability Plot of the Residuals

According to Figure 26, c*onstant variance assumption* approximately holds.

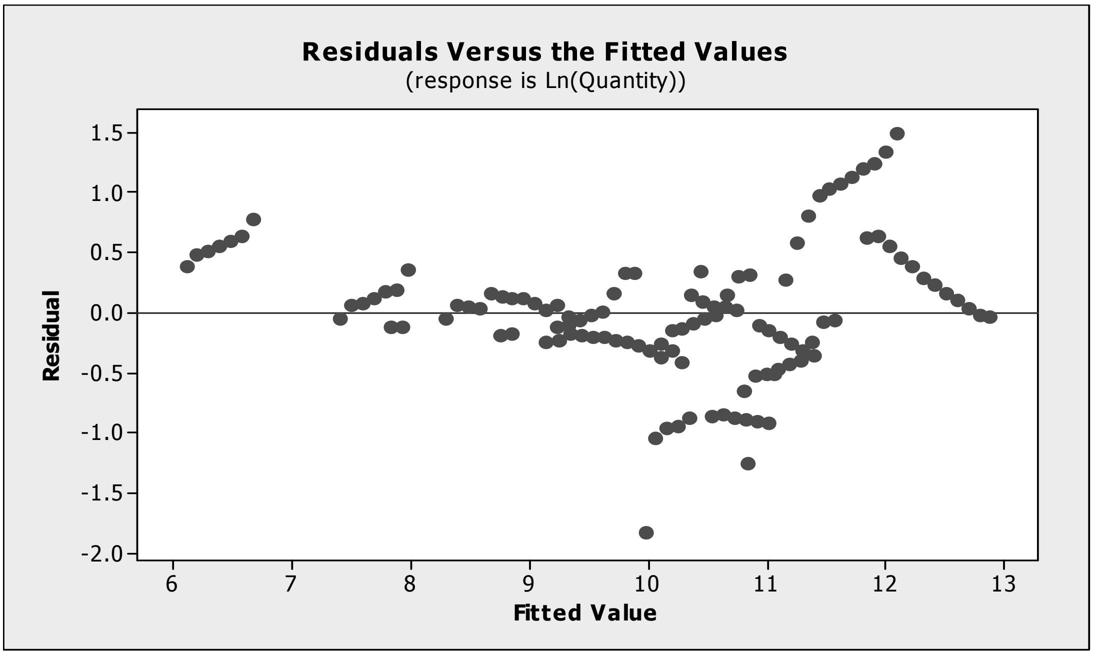

Figure 26: Residuals vs. the Fitted Values

Probability plots of independent variables are shown in Figures 27-29.

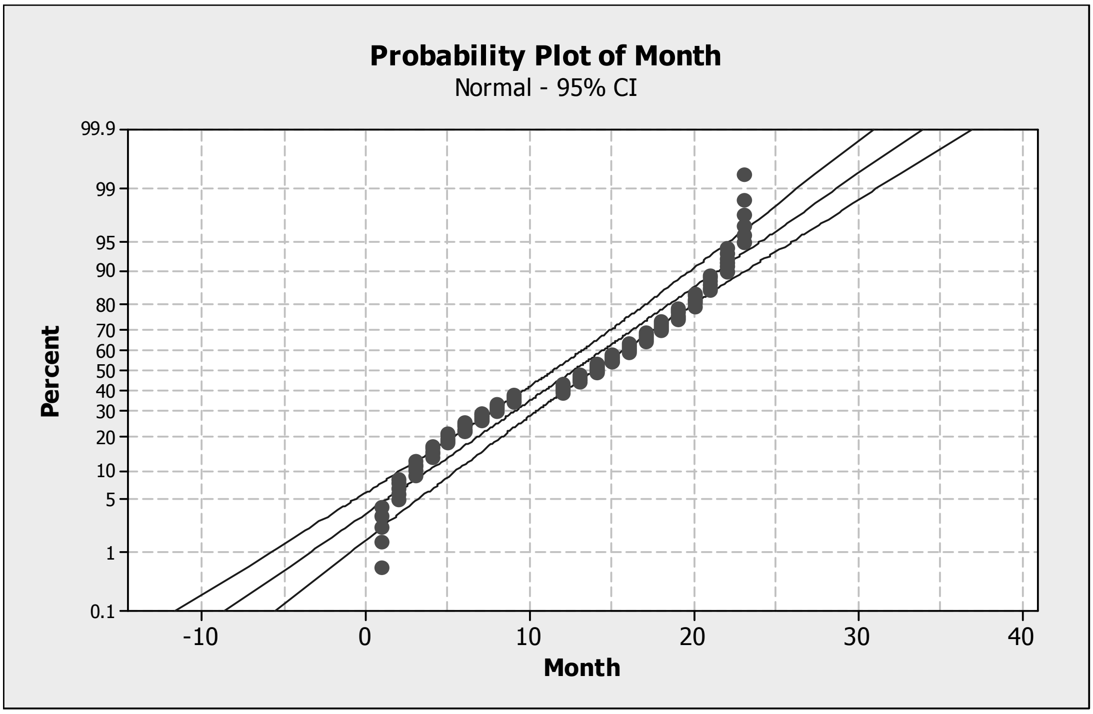

Figure 27: Probability Plot of Month

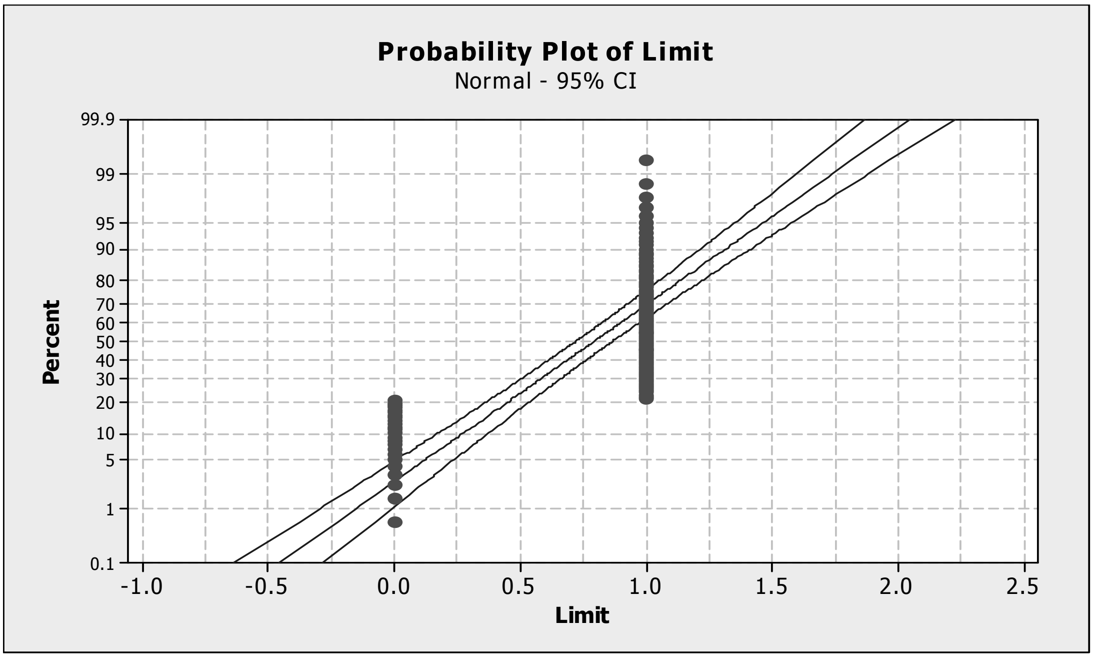

Figure 28: Probability Plot of Limit

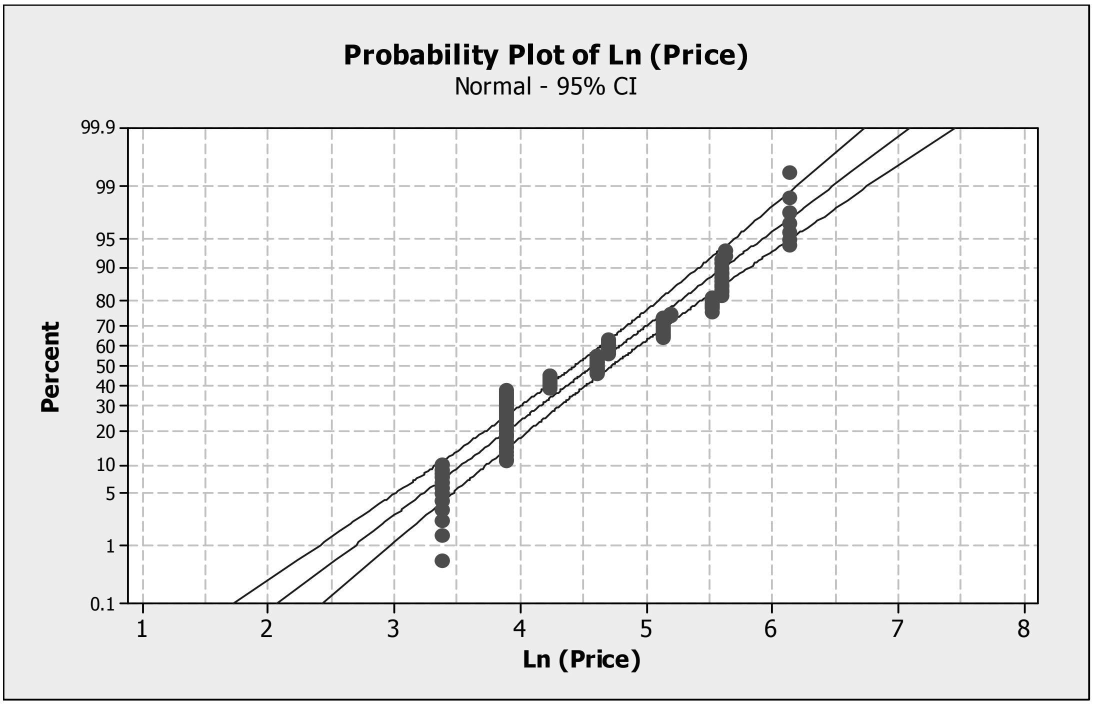

Figure 29: Probability Plot of ln(Price)

APPENDIX D: CONTENTION RATIOS AND COSTS FOR SPECIFIC TELECOM OPERATORS[25]

Table 14: Contention Ratios for Specific Countries

Country	*Minimum*	*Maximum*	*Average*
Czech Republic	4:1	50:1	34:1
Ireland	1:1	50:1	24:1
Slovakia	1:1	45:1	14:1
United Kingdom	1:1	50:1	28:1

Table 15: Monthly Costs According to Download Speed and Contention Ratio

Country	*Download Speed*	*Contention Ratio*	*Monthly Cost (USD)*
Czech Republic	512 Kbps	20:1	$91.33
		40:1	$45.97
		50:1	$43.30
Ireland	512 Kbps	20:1	$114.48
		48:1	$35.33
	1 Mbps	10:1	$78.32
		20:1	$154.67
		48:1	$24.16
	2 Mbps	10:1	$324.84
		48:1	$32.79
Slovakia	1.5 Mbps	20:1	$70.80
		45:1	$46.94
United Kingdom	512 Kbps	10:1	$293.28
		20:1	$83.64
		50:1	$36.88
	1 Mbps	10:1	$387.40
		20:1	$79.82
		50:1	$43.30
	2 Mbps	10:1	$473.11
		20:1	$100.00
		50:1	$51.55

[25] Waiura Consulting Report (2006). Retrieved from http://www.internetnz.net.nz/pubs/other/2006-05-29-oecd-broadband-markets on 13.11.2006

APPENDIX E: DISTRIBUTION OF ADSL USERS ACCORDING TO TRAFFIC (SEPTEMBER 2006)

This appendix includes the monthly usage figures of ADSL subscribers as of September 2006. The usage distributions are estimated from Table 16 by using the sample distribution of 512 Kbps 5 GB subscribers in 2005 for 6 months. The distribution of the 512 Kbps 5 GB subscribers were approximating to the distributions shown in Figures 30 to 36.

Table 16: Distribution of Monthly Usage

Package	< 0.5 GB	0.5-1.0 GB	1.0-2.0 GB	2.0-3.0 GB	3.0-9.0 GB	9.0-20.0 GB	> 20.0 GB
Unlimited 256k	17.7%	13.8%	19.0%	12.5%	27.4%	7.6%	2.0%
Unlimited 512k	12.2%	8.1%	12.5%	9.8%	28.6%	17.8%	11.1%
Unlimited 1 Mb	12.4%	8.8%	13.3%	9.1%	25.8%	13.5%	17.1%
Unlimited 2 Mb	6.3%	4.0%	7.5%	6.1%	24.3%	18.8%	33.1%
Limited 1 Mb - 3G	27.9%	18.2%	23.0%	14.4%	15.7%	0.7%	0.1%
Limited 1 Mb - 6G	19.6%	12.7%	18.3%	12.9%	31.1%	4.8%	0.5%
Limited 1 Mb - 9G	19.6%	11.7%	14.5%	10.7%	29.6%	11.8%	2.0%
Total	**25.2%**	**16.8%**	**21.6%**	**13.7%**	**18.5%**	**2.8%**	**1.4%**

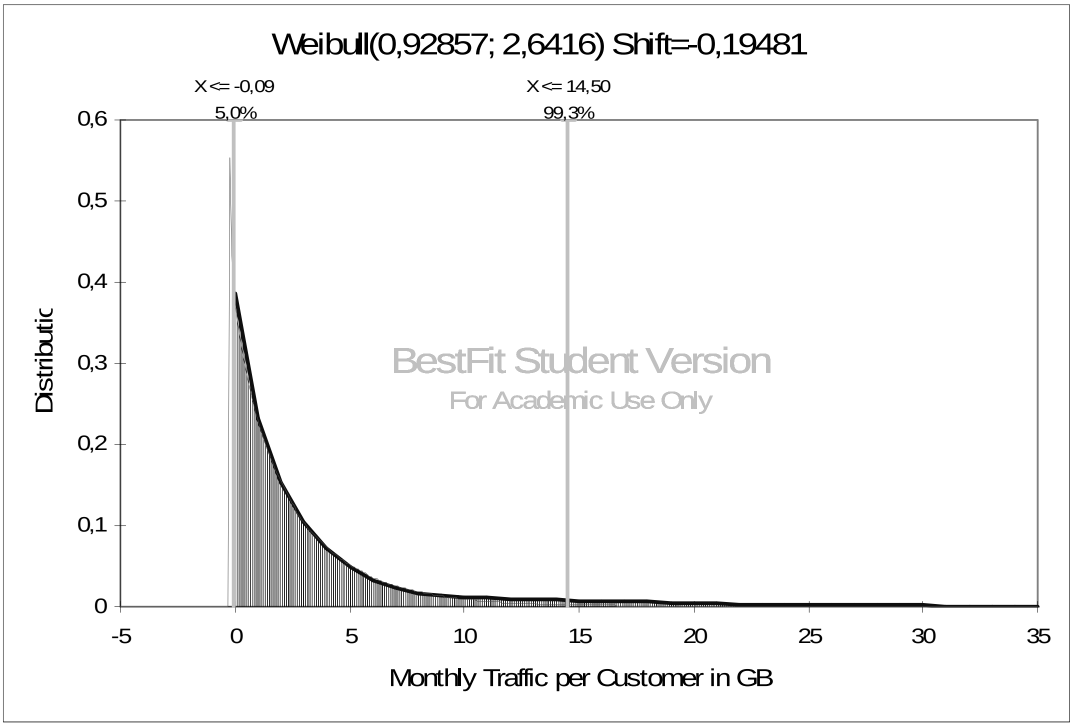

Figure 30: 256 Kbps User Monthly Traffic

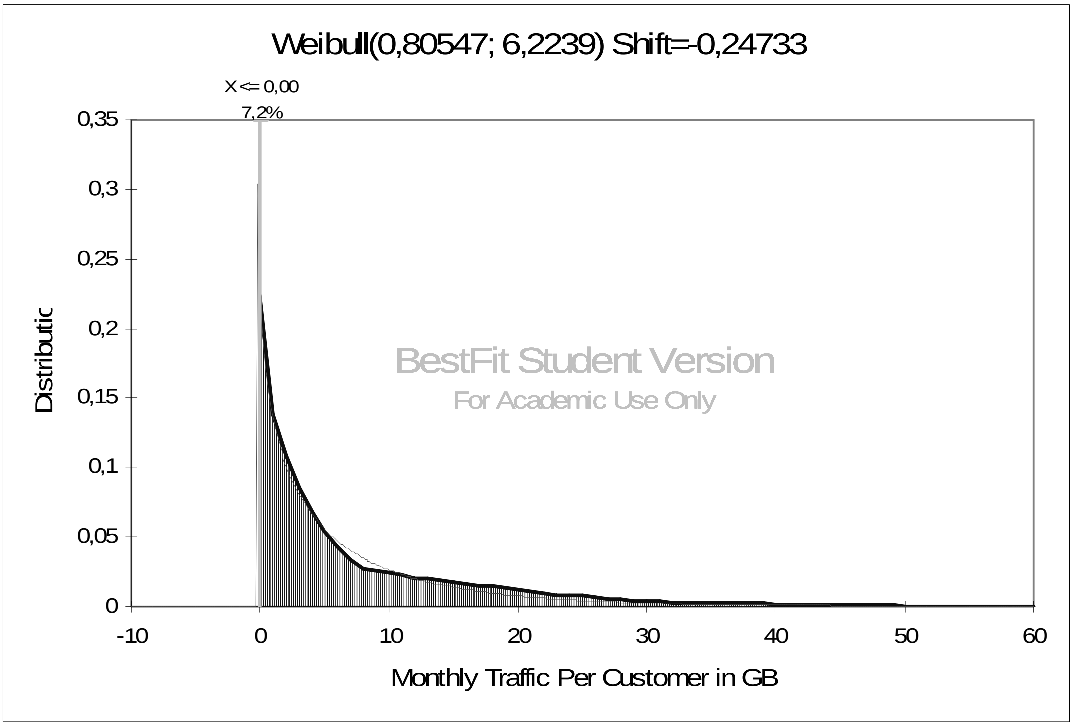

Figure 31: 512 Kbps User Monthly Traffic

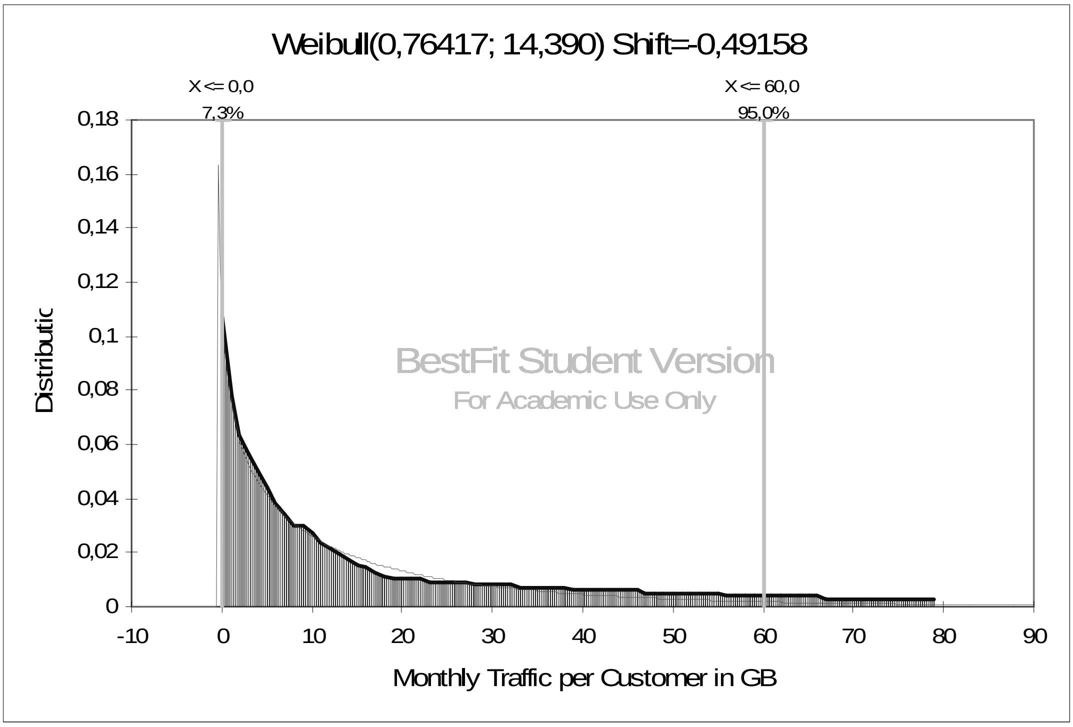

Figure 32: 1024 Kbps User Monthly Traffic

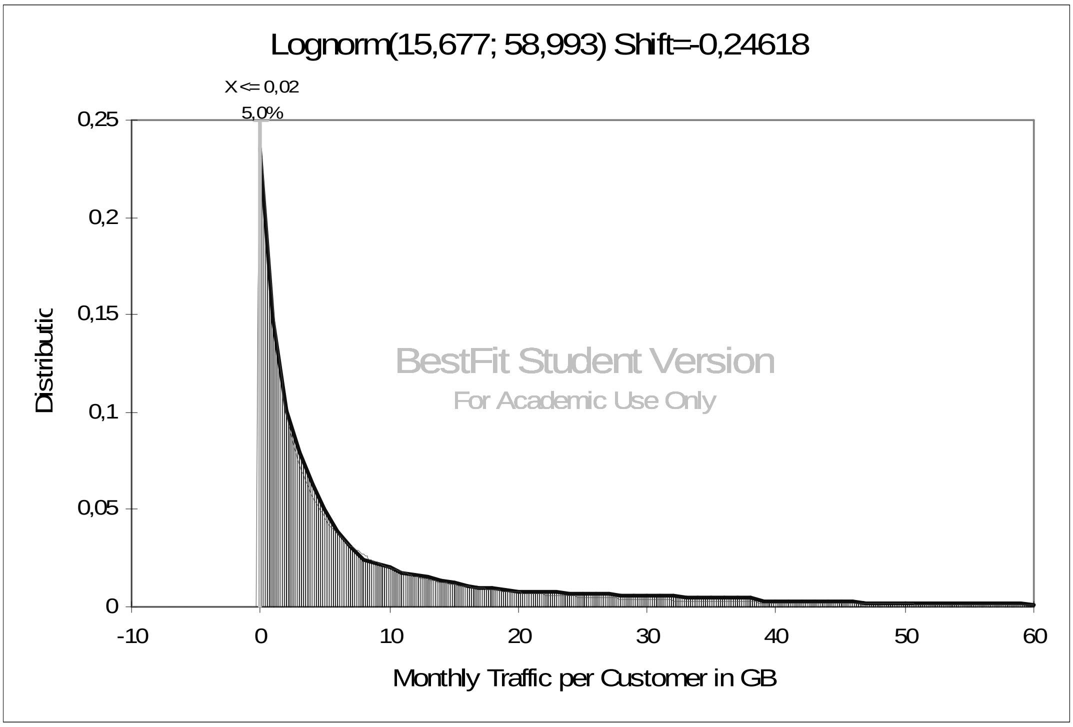

Figure 33: 2048 Kbps User Monthly Traffic

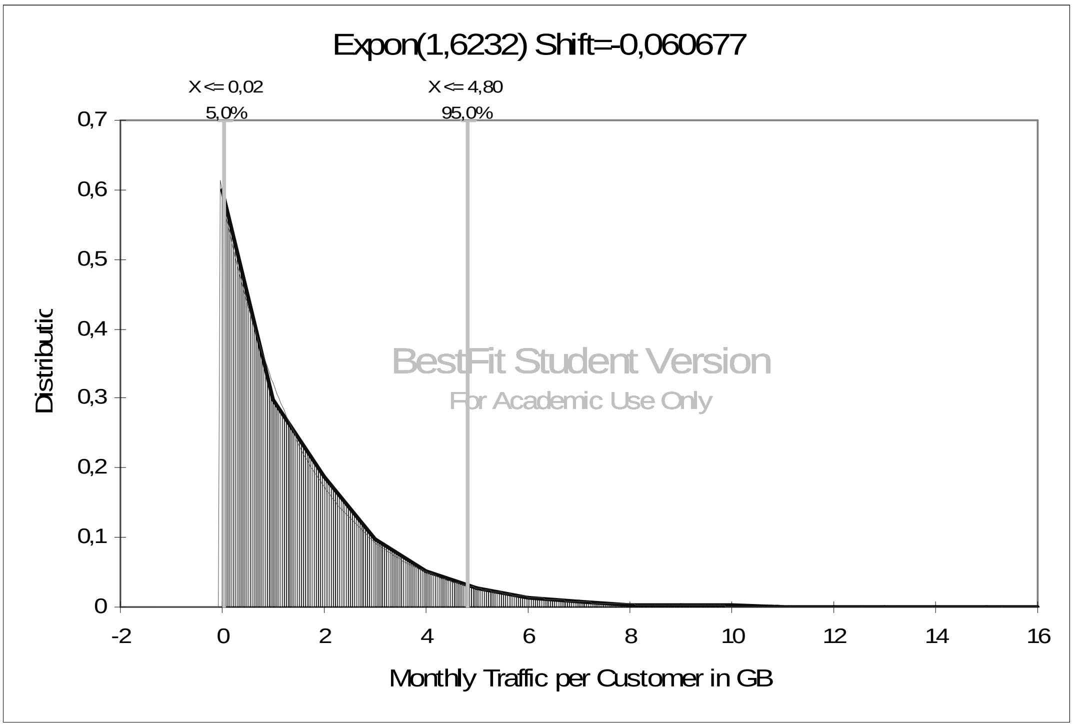

Figure 34: 1024 Kbps 3 GB User Monthly Traffic

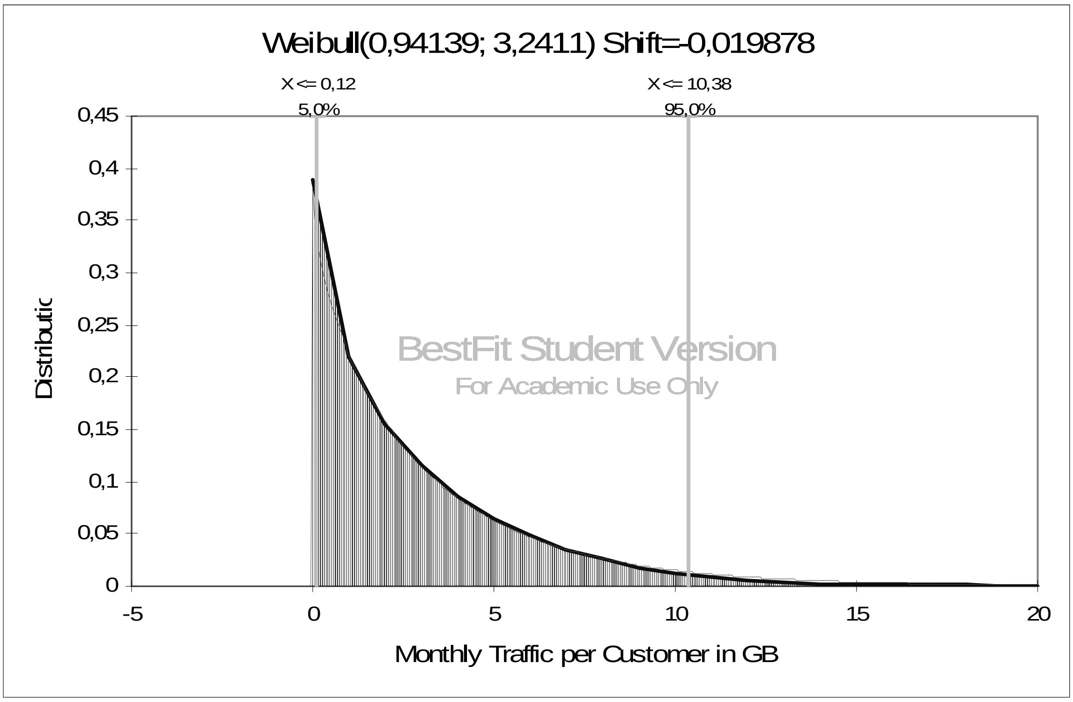

Figure 35: 1024 Kbps 6 GB User Monthly Traffic

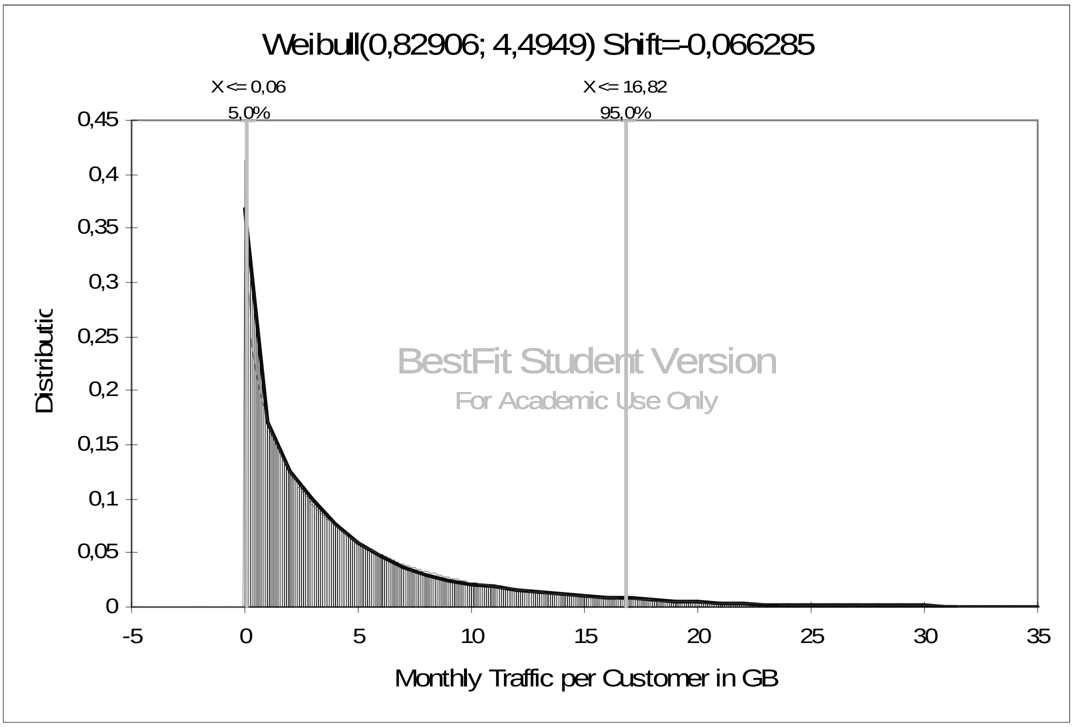

Figure 36: 1024 Kbps 9 GB User Monthly Traffic

APPENDIX F: WACC CALCULATION[26]

Firms finance their investments through either debt or equity or both. WACC (Weighted Average Cost of Capital) is a firm's weighted average of its cost of debt and cost of equity and can be used to discount investments. WACC is based Capital Asset Pricing Model (CAPM) which states:

$R = R_f + \beta \times R_p$

Where,

- R is the expected return on an investment
- R_f is the risk-free rate of return, which is generally the rate of return on long term bonds issued by the Treasury.
- R_p is the risk premium which is defined as the difference between market return rate and risk-free return rate (R_f).
- β (beta) is the measure of responsiveness of a security (firm) to changes in the market (economy). For example, if beta for a security equals 0.8 then 1 percent change in the market results in 0.8 percent change in the security in the same direction.

WACC is calculated as

$$\underbrace{[\text{COE x Equity / (Debt + Equity)}]}_{(1)} + \underbrace{[\text{COD x Debt / (Debt + Equity)}]}_{(2)}$$

Where,

- COE is the cost of equity,

[26] Based on Ross, Westerfield & Jaffe (1999).

- COD is the cost of debt,
- Equity is the value of equity,
- Debt is the value of total debt.

As of end of 2005 Türk Telekom had no debt to be paid. Thus the second half of the equation equals 0. From the first half of the equation, it is inferred that WACC equals Cost of Equity, which is given by the CAPM formula.

$$COE = R_f + \beta \times R_p$$

The investments on ADSL are mainly made in USD currency. As a result, $\mathbf{R_f}$ is assumed as the 2005 monthly average rate on the longest term Eurobonds (30 year) issued by the Treasury rather than rate of return on TL Treasury bonds. This rate equals to *7.76%*[27].

Beta (*1.19*) is calculated as the average of 11 incumbent operators from developing countries, which show similar risk characteristics with Türk Telekom. (Source: Türk Telekom).

According to the investment institutions, $\mathbf{R_p}$ is calculated as *6%*. (Source: Türk Telekom).

The resulting WACC for USD investments is 7.76% + 1.19 x 6% = **14.90%**.

Similarly for TL investments with the same beta and risk premium rates and a risk free rate of return at 19.1% for 5 year TL bonds issued by treasury, WACC is **26.24%** (source: Türk Telekom).

[27] Monthly return rates on Eurobonds are retrieved from http://www.hazine.gov.tr/stat/egosterge/VI-Kamumaliyesi/VI_10_4.xls on 16.11.2006.

APPENDIX G: TÜRK TELEKOM TARIFFS FOR SPECIFIC SERVICES

Wholesale Leased Line Tariff Monthly Rental Fees (TL, Excluding 18% VAT and 15% SCT) [28]

Speed (Mbps)	*Same Exchange*	*Metropolitan*	*Intracity*	*Intercity*
2	342	582	1,320	2,323
34	1,882	3,583	6,579	14,468
155	3,966	7,552	13,867	30,495

Retail ADSL Tariffs (TL, Including 18% VAT and 15% SCT) [29]

Connection Fee: 59 TL

Offer Type	*Monthly Rental (TL)*
256/64 Kbps	*49.00*
512/128 Kbps	*89.00*
1024/256 Kbps	*139.00*
2048/512 Kbps	*229.00*
1024 Kbps /w 3 GB download *	*29.00*
1025 Kbps /w 6 GB download *	*49.00*
1026 Kbps /w 9 GB download *	*69.00*

* Above quota price is 0.01 TL per MB download. Total monthly fee to be paid by a subscriber is limited to 1.25 times the unlimited offer at the same speed (1024/256 Kbps).

[28] Wholesale tariffs are applicable to operators having signed contract with Telecommunications Authority with at least 50 x 2 Mbps or comparable amount of capacity.

[29] Retail level ADSL is not offered by Türk Telekom. Since 2 June 2006 TTNet, subsidiary of Türk Telekom, offers retail level ADSL together with other Internet Service Providers.

Wholesale ADSL Tariff Monthly Rental Fees (TL, Including 18% VAT and 15% SCT) [30]

Connection Fee: 59 TL

Offer Type	*Monthly Rental (TL)*
256/64 Kbps	40.18
512/128 Kbps	72.98
1024/256 Kbps	113.98
2048/512 Kbps	187.78
1024 Kbps /w 3 GB download *	23.78
1025 Kbps /w 6 GB download *	40.18
1026 Kbps /w 9 GB download *	56.58

*Above quota price is 0.0082 TL per MB download. Total monthly fee to be paid by a subscriber is limited to 1.25 times the unlimited offer at the same speed (1024/256 Kbps).

Starter Package ADSL Price Development

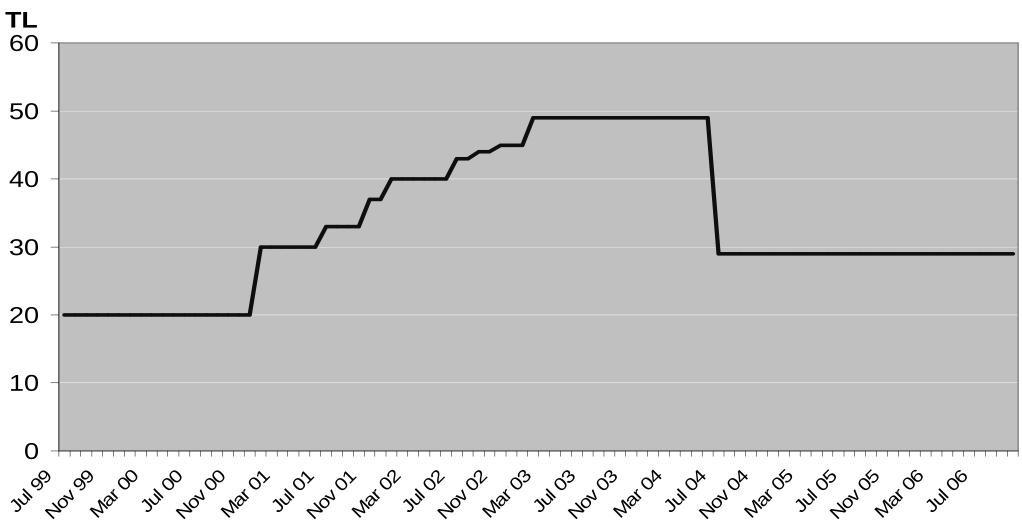

Figure 37: Change of Lowest Monthly Rental Fee (Starter Package)

30 Wholesale offer is available to Internet Service Providers only. It is determined on retail minus basis and is 18% lower than the retail tariffs.

APPENDIX H: RETAIL TARIFF BENCHMARKS

Prices in this section are in Turkish Lira (TL) adjusted to Purchasing Power Parity including VAT and for Turkey additional SCT. Price figures are taken from Teligen International T-World Total Software. Purchasing Power Parity adjustment has been made according to the OECD 2005 figures[31].

Retail Tariff Comparisons

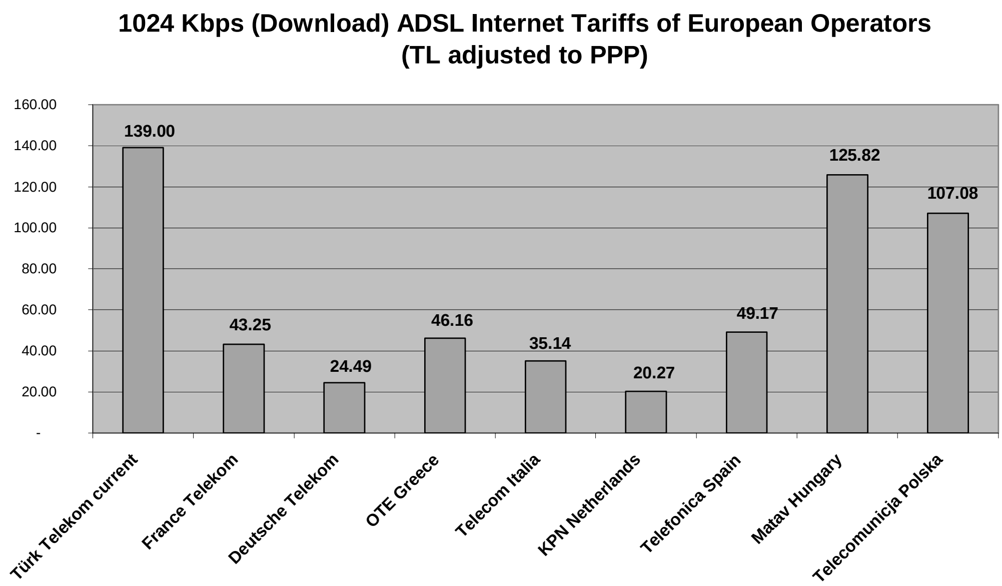

Figure 38: 1024 Kbps Monthly Rental Comparison

[31] Retrieved from http://www.oecd.org/dataoecd/61/54/18598754.pdf on 14.11.2006

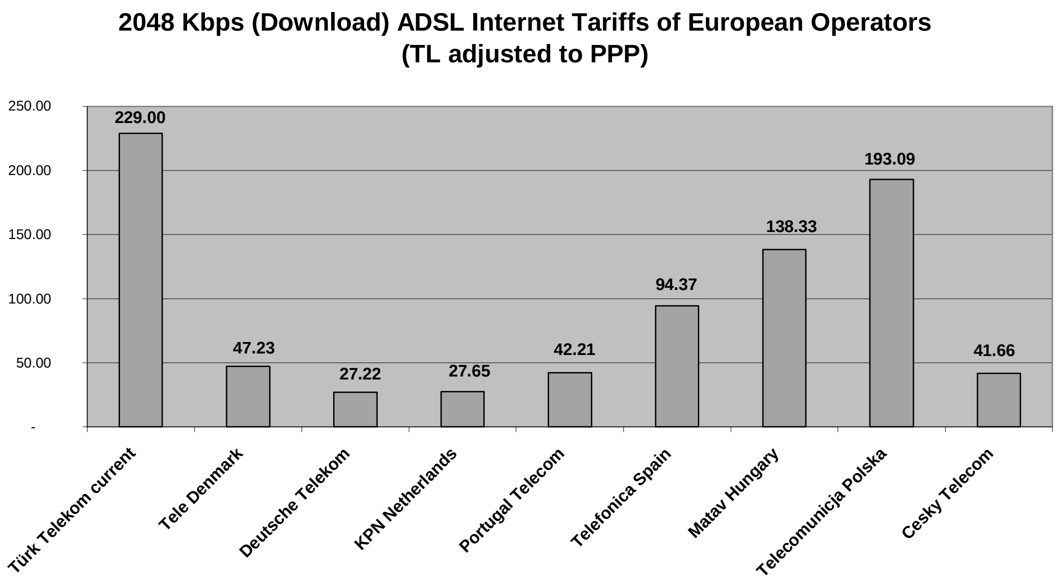

Figure 39: 2048 Kbps Monthly Rental Comparison

Tariffs of International Operators

Table 17: Tariffs of International Operators

Operator	Country	Name	Type	Download/ Upload (Kbps)	Quota	Over-quota Charge		Monthly Rental (TL)	Connection Fee (TL)	Additional Information
TTNET	Turkey	TTNET ADSL	Residential and Business	256/64	Unlimited			49.00	59.00	Requires telephony subscription, which has a minimum monthly rental of 7.2 TL. 1 mailbox with 10 MB.
		TTNET ADSL	Residential and Business	512/12	Unlimited			89.00	59.00	
		TTNET ADSL	Residential and Business	1024/256	Unlimited			139.00	59.00	
		TTNET ADSL	Residential and Business	2048/512	Unlimited			229.00	59.00	
		TTNET ADSL	Residential and Business	1024/256	3 GB	0.01	per MB	29.00	59.00	
		TTNET ADSL	Residential and Business	1024/256	6 GB	0.01	per MB	49.00	59.00	
		TTNET ADSL	Residential and Business	1024/256	9 GB	0.01	per MB	69.00	59.00	
Telekom Austria	Austria	Residential	Residential	384/128	400 MB	0.07	per MB	18.62	129.04	Modem is provided by Telekom Austria
		Residential	Residential	1024/256	800 MB	0.07	per MB	27.98	129.04	
		Residential	Residential	1024/256	2 GB	0.07	per MB	37.34	129.04	
		Residential	Residential	1024/256	5 GB	0.07	per MB	42.01	129.04	
		Residential	Residential	2048/384	15 GB	0.07	per MB	51.37	129.04	
		Business	Business	384/128	800 MB	0.06	per MB	32.56	213.35	20 mailboxes, 100 MB Web Space, DNS
		Business	Business	1024/256	5 GB	0.06	per MB	50.53	213.35	
		Business	Business	2048/512	10 GB	0.06	per MB	71.86	213.35	
		Business	Business	3072/512	20 GB	0.06	per MB	94.32	213.35	
		Business	Business	4096/512	25 GB	0.06	per MB	122.39	213.35	
		Business Access Pro	Business	2048/512	15 GB	0.06	per MB	88.71	325.64	Router Included, 50 Mailboxes, 100 MB Web Space, DNS
		Business Access Pro	Business	3072/512	15 GB	0.06	per MB	111.17	325.64	
		Business Access Pro	Business	4096/512	25 GB	0.06	per MB	144.85	325.64	
		Business Access Pro	Business	5952/512	25 GB	0.06	per MB	178.54	325.64	
		Business Access Pro	Business	2048/512	Unlimited			122.39	325.64	
		Business Access Pro	Business	3072/512	Unlimited			144.85	325.64	

Table 17 (cont.): Tariffs of International Operators

		Business Access Pro	Business	4096/512	Unlimited			178.54	325.64	
		Business Access Pro	Business	5952/512	Unlimited			212.23	325.64	
Cesky Telecom	Czech Rep.	Internet Expres Impuls	Residential	512/128	Unlimited			27.75	105.03	
		Internet Expres Ideal	Residential	2048/256	Unlimited			41.66	105.03	
		Internet Expres Sprint	Residential	3072/256	Unlimited			55.58	105.03	
		Internet Expres Maxi	Residential	4096/512	Unlimited			83.40	105.03	
		Internet Expres Extreme 512	Business	512/128	Unlimited			62.53	105.03	
		Internet Expres Extreme 2048	Business	2048/256	Unlimited			76.44	105.03	
		Internet Expres Extreme 3072	Business	2072/256	Unlimited			97.31	105.03	
		Internet Expres Extreme 4096	Business	4096/512	Unlimited			125.13	105.03	
		Internet Broadband 512/128	Business	512/128	3 GB	13.91	per 5 GB	54.39	105.03	10 MB Mailbox, 10 MB webspace
		Internet Broadband 512/128	Business	512/128	6 GB	13.91	per 5 GB	62.74	105.03	
		Internet Broadband 512/128	Business	512/128	10 GB	13.91	per 5 GB	78.04	105.03	30 MB Mailbox, 30 MB webspace
		Internet Broadband 1024/256	Business	1024/256	6 GB	13.91	per 5 GB	94.04	105.03	10 MB Mailbox, 10 MB webspace
		Internet Broadband 1024/256	Business	1024/256	12 GB	13.91	per 5 GB	110.73	105.03	
		Internet Broadband 1024/256	Business	1024/256	20 GB	13.91	per 5 GB	134.38	105.03	30 MB Mailbox, 30 MB webspace
		Internet Broadband Profi	Business	256/64	Unlimited			134.38	105.03	
		Internet Broadband Profi	Business	512/128	Unlimited			198.79	105.03	
		Internet Broadband Profi	Business	1024/256	Unlimited			386.59	105.03	
Tele Denmark	Denmark	Volume TDC Broadband 2048/128	Residential and Business	2048/128	-	0.07	per MB	9.86	69.25	Minimum contract period is 6 months
		Unlimited TDC Broadband 160/128	Residential and Business	160/128	Unlimited			19.83	69.25	
		Unlimited TDC Broadband 256/128	Residential and Business	256/128	Unlimited			23.81	69.25	
		Unlimited TDC Broadband 512/128	Residential and Business	512/128	Unlimited			29.79	69.25	

Table 17 (cont.): Tariffs of International Operators

		Unlimited TDC Broadband 1024/128	Residential and Business	1024/128	Unlimited			35.77	69.25	
		Unlimited TDC Broadband 1024/512	Residential and Business	1024/512	Unlimited			43.24	69.25	
		Unlimited TDC Broadband 2048/128	Residential and Business	2048/128	Unlimited			39.76	69.25	
		Unlimited TDC Broadband 2048/512	Residential and Business	2048/512	Unlimited			47.23	69.25	
		Capped TDC Broadband 4096/256	Residential and Business	4096/256	5 GB	0.02	per MB	49.72	69.25	Minimum contract period is 6 months. Maximum charge is 899 Dkr.
		Capped TDC Broadband 4096/512	Residential and Business	4096/512	5 GB	0.02	per MB	57.19	69.25	Minimum contract period is 6 months. Maximum charge is 999 Dkr.
		Capped TDC Broadband 8064/512	Residential and Business	8064/512	5 GB	0.02	per MB	79.61	69.25	Minimum contract period is 6 months. Maximum charge is 1199 Dkr.
France Telecom	France	ADSL Reference	Residential	512/128	Unlimited			17.94	58.33	Minimum contract period is 12 months
		ADSL Exigence	Residential	1024/128	Unlimited			21.16	58.33	
		Le Compte 512	Residential	512/128	1 Hour	0.92	per Hour	9.20	58.33	
		Internet 1M	Residential	1024/256	Unlimited			22.91	27.61	Minimum contract period is 12 months. 5 E-mail, 100 MB Webspace
		Internet 8 M	Residential	8M/800	Unlimited			27.51	27.61	
		Internet 18 M	Residential	18M/800	Unlimited			36.72	27.61	
		Internet Pro 1M	Business	1024/256	Unlimited			33.92	72.69	Minimum contract period is 12 months. 20 E-mail with 20 Mb, 100 MB Webspace
		Internet Pro Max	Business	8M/800	Unlimited			38.52	72.69	
		Internet Pro Max 18	Business	18M/800	Unlimited			47.72	72.69	
Deutsche Telecom	Germany	T-DSL 1000 /w T-Online dsl start	Residential	1024/128	30 Hours	0.01	per MB	19.95	90.86	Requires telephony subscription which has a minimum monthly rental of 15.95 € .
		T-DSL 1000 /w T-Online dsl flat	Residential	1024/128	Unlimited			24.49	90.86	
		T-DSL 2000 /w T-Online dsl start	Residential	2048/192	30 Hours	0.01	per MB	22.67	90.86	
		T-DSL 2000 /w T-Online dsl flat	Residential	2048/192	Unlimited			27.22	90.86	
		T-DSL 6000 /w T-Online dsl start	Residential	6016/576	30 Hours	0.01	per MB	27.22	90.86	

Table 17 (cont.): Tariffs of International Operators

		T-DSL 6000 /w T-Online dsl flat	Residential	6016/576	Unlimited			31.76	90.86	
		T-DSL 16000 /w T-Online dsl start	Residential	16000/1024	30 Hours	0.01	per MB	31.76	90.86	
		T-DSL 16000 /w T-Online dsl flat	Residential	16000/1024	Unlimited			36.31	90.86	
		T-DSL Business 1000	Business	1024/128	2 GB	0.02	per MB	27.18	90.86	
		T-DSL Business 2000	Business	2048/192	2 GB	0.02	per MB	29.91	90.86	
		T-DSL Business 6000	Business	6016/576	5 GB	0.01	per MB	36.27	90.86	
		T-DSL Business 1000 flatrate	Business	1024/128	Unlimited			32.55	90.86	
		T-DSL Business 2000 flatrate	Business	2048/192	Unlimited			35.27	90.86	
		T-DSL Business 6000 flat rate	Business	6016/576	Unlimited			41.64	90.86	
OTE	Greece	OnDSL Home 384/128	Residential	384/128	Unlimited			48.83	112.22	
		OnDSL Home 512/128	Residential	512/128	Unlimited			69.87	112.22	
		OnDSL Economy 1000	Residential	384/128	1 GB	0.02	per MB	36.19	112.22	Maximum charge is 71.4 €
		OnDSL Economy 1000	Residential	512/128	1 GB	0.02	per MB	41.81	112.22	
		OnDSL Economy 1000	Residential	1024/256	1 GB	0.02	per MB	60.05	112.22	
		OnDSL Economy 3000	Residential	384/128	3 GB	0.02	per MB	43.21	117.84	Maximum charge is 59.5 €
		OnDSL Economy 3000	Residential	512/128	3 GB	0.02	per MB	48.82	117.84	
		OnDSL Economy 3000	Residential	1024/256	3 GB	0.02	per MB	67.06	117.84	
		OnDSL Office Basic	Business	384/128	Unlimited			76.88	117.84	
		OnDSL Office Basic	Business	512/128	Unlimited			103.54	117.84	
		OnDSL Office	Business	384/128	Unlimited			92.31	117.84	
		OnDSL Office	Business	512/128	Unlimited			125.99	117.84	
EirCom	Ireland	Home Time	Residential	1024/128	20 Hours	0.03	per minute	16.59	165.71	Router is free of charge. Minimum contract period is 12 months. Excess usage is capped at 30 €

Table 17 (cont.): Tariffs of International Operators

		Home Starter	Residential	1024/128	10 GB	0.01	per MB	24.89	165.71	Router is free of charge. Minimum contract period is 12 months.
		Home Plus	Residential	2048/256	20 GB	0.01	per MB	33.19	165.71	
		Home Professional	Residential	3072/384	30 GB	0.01	per MB	45.19	165.71	
		Business Time	Business	1024/128	20 Hours	0.03	per minute	16.59	82.16	
		Business Startee	Business	3072/384	20 GB	0.01	per MB	45.19	82.16	
		Business Plus	Business	4096/384	40 GB	0.01	per MB	89.38	82.16	
		Business Enhanced	Business	5120/512	Unlimited			169.73	82.16	
Telecom Italia	Italy	Alice Free	Residential	640/256	-	1.95	per hour	-	178.50	1 Mailbox and 3 GB Webspace
		Alice Night & Weekend	Residential	640/256	-	1.95	per hour	9.72	151.16	Limited to all night from 23.00 to 6.00 and all day Saturdays and Sundays. 1 Mailbox and 3 GB Webspace.
		Alice Flat	Residential	640/256	Unlimited			19.48	151.16	1 Mailbox and 3 MB Webspace
		Alice 20 Mega	Residential	20480/384	Unlimited			36.08	151.16	
		Alice Business Free	Business	640/256	-	2.46	per Hour	3.50	146.47	1 Mailbox and 50 MB Webspace
		Alice Business Flat	Business	640/256	Unlimited			26.94	151.16	
		Alice Business 1	Business	1280/256	Unlimited			42.17	87.88	
		Alice Business 5	Business	4096/256	Unlimited			46.87	87.88	5 Mailbox and 50 MB Webspace
		Alice Business 5 Fast	Business	4096/256	Unlimited			45.70	271.85	5 Mailbox and 20 MB Webspace
		Alice Business 10 Fast	Business	2048/256	Unlimited			132.41	87.88	10 Mailbox and 50 MB Webspace
KPN Telecom	Netherlands	ADSL Go	Residential	1500/256	Unlimited			20.27	69.20	
		ADSL Lite	Residential	3000/512	Unlimited			27.65	69.20	
		ADSL Basic	Residential	6000/768	Unlimited			46.12	69.20	
		ADSL Extra	Residential	12000/1024	Unlimited			69.20	69.20	
Polish Telecom	Poland	DSL 500	Residential	512/128	Unlimited			89.88	343.61	
		DSL 1000	Residential	1024/256	Unlimited			107.08	343.61	
		DSL 2000	Residential	2048/256	Unlimited			193.09	343.61	
		ADSL	Business	256/64	Unlimited			445.44	366.74	

Table 17 (cont.): Tariffs of International Operators

		ADSL	Business	512/128	Unlimited			518.89	445.44	
		ADSL	Business	1024/128	Unlimited			550.37	524.14	
		ADSL	Business	2048/256	Unlimited			629.07	550.37	
Portugal Telecom	Portugal	Free	Residential	256/128	-	0.04	per 10 minute	-	148.57	25 MB Web space, 2 Mailboxes with 1 GB each, POP 3
		Pre-Pago	Residential	256/128	-	0.35	per 10 minute	-	148.57	
		Light	Residential	256/128	15 Hours	0.30	per 10 minute	27.05	148.57	
		2 Mb	Residential	2048/128	*	0.12	per 100 MB national	42.07	148.57	* 20 GB National and 2 GB International Traffic. 25 MB Web space, 2 Mailboxes with 1 GB each, POP 3
		4 Mb	Residential	4096/256	*	0.12	per 100 MB national	46.76	148.57	* 40 GB National and 2 GB International Traffic. 25 MB Web space, 2 Mailboxes with 1 GB each, POP 3
		8 Mb	Residential	8128/384	*	1.77	per 100 MB Inter-national	72.12	148.57	* 8 GB International Traffic. 25 MB Web space, 2 Mailboxes with 1 GB each, POP 3
		Work	Business	2048/128	Unlimited			42.21	29.56	2 Mailboxes
		4 MB	Business	4096/256	Unlimited			107.30	29.56	10 Mailboxes
		8 MB	Business	8128/384	Unlimited			171.68	29.56	20 Mailboxes
Telefonica	Spain	Linea ADSL Basica	Residential and Business	1024/320				49.17	47.95	4 e-mail with 25 MB and 1 e-mail with 100 MB
		Linea ADSL Class	Residential and Business	2048/320				94.37	47.95	
		Linea ADSL Avanzada	Residential and Business	4096/512				151.03	47.95	
		Linea ADSL Premium	Residential and Business	8192/640				188.78	47.95	

Table 17 (cont.): Tariffs of International Operators

BT	UK	BT Option 1	Residential	2048/256	2 GB *			23.81	-	* Charges after exceeding usage monthly allowance: more than 1GB is charged GBP 4.00 extra, more than 3 GB is charged GBP 8.00 extra and more than 6 GB is charged GBP 12.00 extra. Minimum Contract Period is 12 months.
		BT Option 2	Residential	2048/256	2 GB *			30.43	-	
		BT Option 3	Residential	8192/256	20 GB *			35.73	-	
		BT Option 4	Residential	8192/256	40 GB *			39.70	-	
		Single	Business	8000/448	Unlimited			46.65	-	Business users pay quarterly in advance. Includes 10 e-mail addresses and 20 MB webspace. Minimum Contract Period is 12 months.