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STRATEGIC CHOICES OF FIRMS IN DEVELOPING COUNTRIES BETWEEN TECHNOLOGY TRANSFER AND R&D

DOKTORA TEZİ /Ph.D. THESIS

Serap OĞUZ

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ABSTRACT

There are studies that analyze the strategic choices of firms in developing countries, between research and development and technology transfer, for their effects on productivity. Most of these studies concentrate on, how technology transfer affected domestic research and development over years and some mention about the trigger effect of technology transfer on domestic research activities, which may go up to formation of the technology buyer firm's own technology.

In this study, Turkish container glass sector is chosen as the example sector and the market conditions are analyzed first to form a basis for the incentives of innovative activities. The dominant supplier firm in the market, Sisecam faces competition both from the supplementary products sectors and from the international competitors. Production and cost data of the last 14 years is used to analyze and compare the effects of both technology transfer and research and development activities, which gained weight compared to technology transfer during these years. Effects on different cost items are presented separately as well as the changes in pricing.

Results have supported Schumpeterian view that even a dominant firm may have incentive for innovative activity as long as the contestable market conditions are satisfied, besides achievement is much more probable for dominant firms as they have enough financial means to carry out serious development projects. It is shown that, incentive of Sisecam due to market conditions caused intensification of innovative activities and research and development has been more productive, mainly on labor productivity. A decreasing trend in prices in parallel with costs is visible.

ÖZET

Gelişmekte olan ülkelerde firmaların araştırma geliştirme faaliyetleri ve teknoloji transferi arasındaki stratejik seçimleri ve bunların verimlilik üzerindeki etkileri üzerine çalışmalar mevcuttur. Bu çalışmaların çoğu, yıllar boyunca teknoloji transferinin araştırma geliştirme çalışmaları üzerindeki olumlu ya da olumsuz etkileri üzerinde yoğunlaşır ve kimi, teknoloji transferinin, teknoloji alan firmanın kendi teknolojisini oluşturmasına kadar giden araştırma geliştirme faaliyetleri üzerindeki tetikleyici etkisinden bahsederler.

Bu çalışmada Türk cam ambalaj sektörü örnek sektör olarak seçilmiş ve ilk olarak geliştirme faaliyetlerine yönelik motivasyonlara baz teşkil etmek üzere pazar şartları analiz edilmiştir. Pazarda hakim konumdaki firma Şişecam, hem ikame mallar hem de uluslararası rakipleriyle rekabet etmektedir. Teknoloji transferi ve son zamanlarda ağırlık kazanan araştırma geliştirme çalışmalarının etkilerini kıyaslamak üzere son 15 yıllık üretim ve faaliyet datası kullanılmıştır. Farklı maliyet faktörleri ve fiyatlar üzerindeki değişim ve etkileşim ayrı ayrı sunulmuştur.

Sonuçlar, Schumpeter'in hakim konumdaki bir firmanın da rekabetçi pazar şartları sağlandıkça, geliştirme faaliyetlerinde bulunma konusunda motivasyonunun ve bunun ötesinde ciddi geliştirme projelerini yürütmek için yeterli finansal gücünün bulunmasına bağlı olarak başarıya ulaşma ihtimalinin daha yüksek olacağı konusundaki görüşünü desteklemektedir. Şişecam'ın pazar şartlarından dolayı oluşan motivasyonunun geliştirme faaliyetlerinin yoğunlaşmasına neden olduğu ve araştırma geliştirme faaliyetlerinin özellikle işgücü üzerinde verimliliği arttırmada daha etken olduğu gösterilmiştir. Fiyatlarda da maliyetlere paralel bir düşüş trendi görülebilmektedir.

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1 INTRODUCTION

The scope of the thesis is to discuss the strategic choices of firms in developing countries between technology transfer from developed countries and domestic research and development activities, Turkish container glass sector being an example.

There are some studies concentrated mainly on India, Brazil and Canada, but these were on the analysis of all industries active in the country and based on the general technology innovation policy. Especially India was referred to be a country, where technologic developments began to be domestically created with the learning effect of imported technologies. Almost all these studies were based on the patent registrations in the relevant countries.

The interesting point in this study is hidden in the example sector selected. This study is concentrated only on a single industry, container glass, which is dominated by a single firm, Şişecam, who has a significant place in the world market as well. Glass industry is among the industries; Turkey has competitive power in the world trade. As glass is a diverse industry, container glass division is selected among, due to its interesting conditions of competition.

Container glass is consumed by many sectors like food, soft drinks, wine, beer, other alcoholic drinks, cosmetics and pharmaceutical industries. Each has highly specific conditions of competition. Whilst enjoying a comfortable dominant position in the container industry in the past, as the case in all around the world, Turkish container industry faced a serious threat from the substitutive packing materials and nearly wiped out of market in some consuming sectors. Threat for others continues to exist. Considering the international competition in the container glass market as well, the dominant firm, Şişecam, began to fight in several arenas and increased the spending on innovative activities.

Share of technology import from the container glass producers in developed countries and domestic R&D activities in this budget has changed considerably over the past years. Whilst the spending on technology import was of higher amount in the past, the percentage and absolute amount it has decreased, and spending on domestic research activities increased over the years. Analysis will be concentrated on this point and the trigger effect of technology transfer on domestic research activities will be discussed.

Another interesting feature of container glass industry is the size of the sole giant firm in the market, and its highly integrated form. Schumpeterian approach to the degree of innovative tendency in the markets, which are not perfectly competitive, worthwhile to highlight here. Following the attack of the substitutive packaging materials in to the market the dominant firm's tendency towards the intensive innovative activities rose up, as the necessary conditions were formed, and as the competitor is not easy to rout with financial strategies. The main competitor of container glass here as the substitutive pack for some consumer industries referred above is PET (Polyethylene Terphtalate) that has the Petrochemical industry behind. Petrochemical industry continues on intensive research activities as well to seize the other strongholds of container glass industry.

Within this frame, trends of glass industry in the world and in Turkey will be explained with its specifics, container glass being the focus, the threats it is facing in the recent years will be referred to form a familiarity basis to the sector for further analysis. Situation of Turkish glass industry will be related with the theory of market classification in the next chapter and conditions of competition will be explained to indicate the motives of innovative activities.

Before the model, as it is the core of the thesis Research and Development theory will be explained. Similar studies carried out in other developing countries will briefly be discussed and in the model, statistical analysis of 14-year data of container glass division of Turkish glass producer, Türkiye Şişe ve Cam Fabrikaları A.Ş, will be carried out. The changes in the price cost margins over the years in cyclic changes will be related to the business cycles in the industry; however, older data couldn't be found to highlight the changes after substitutive containers' challenge.

The concluding remarks will be on the trigger effect of the imported technology over self-technology creation of container glass industry of Turkey, the motives behind it, considering the almost monopolistic market conditions in the industry. Similarities between other studies focused on other countries will be referred.

2 GLASS SECTOR

2.1 DESCRIPTION AND CLASSIFICATION OF THE SECTOR

According to the ASTM[1] standards glass is an inorganic melting product, which cannot find a chance for crystallisation during the process of cooling to solid state. Glass products are metal oxides composed of Silica, Sodium and Calcium Carbonate, Feldspar, Borax and some other raw materials for coloring the glass. All related to the glass products produced by melting the batch (Raw material recipe) or cullet and the products handed by applying some processes to glass are involved in the scope of the sector. Glass production depends on melting technology; so it is energy intensive; where process is to be without interruption. It is a capital-intensive industry and requires continuous investment.

Classification of the glass products can be made according to several categories: according to the oxide content to ease melting, bonding and Vitrification; according to main oxides; according to shaping technique used or according to purpose of use. The last one is the most widely accepted one in the market dividing glass sector to five main groups; Flat Glass, Container Glass, Tableware, Glass fiber, Technical Glass.

According to the International Standards of Industrial Classification - ISIC Glass and glass products sector is classified under Stone and Soil dependent sectors heading with 3620 sub-sector number. Moreover, there are 2610 sub-sectors, defined in the scope of the glass sector. According to General Nomenclature of Economic Activities in the European Activities in the European Communities - NACE, glass and glass products

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[1] American Society for Testing and Materials

sector is referred with sector number 247.

Glass sector is defined as critical sector worldwide, especially in USA and EU where, it has precedence in protectionist policies. In Turkey, the only supplier firm is Türkiye Şişe ve Cam Fabrikaları A.Ş. (Şişecam) who employs the most recent technology in the world.

2.2 MARKET OVERVIEW

The glass industry is very diverse, with glass being an essential material for a variety of end user sectors, including construction, automotive industry, food and drinks packaging, electronics and telecommunications. As glass is still largely a commodity product, much of the growth in the industry has been on a geographic basis in line with economic developments. Estimates indicate that the annual progression is around 2.5-3% all around the world, with the Asia-Pacific accounting for the fastest growth, as the end-user market there has developed very quickly. By contrast, sales growth in Western Europe, Japan and North America has been much slower, the glass industry there, has had to contend with the increasing imports from emerging markets, where production costs are lower (especially labor cost). Therefore, the increase in the glass sector in developing countries is undermining the competitiveness of the glass industry in developed countries. World production of glass by region in the world is shown in Fig. 2.1.

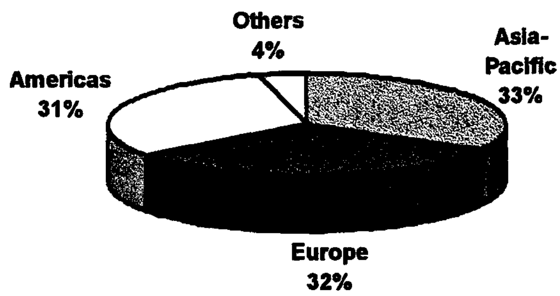

Figure 2-1 World Production of Glass by Region, 1998 (World Glass File,1999,p:15)

There are relatively few integrated glass manufacturers in the world, as most glass companies tend to specialise in one or two sectors of the industry. The most important exception to this is Saint Gobain of France and Owens Illinois of US, which in addition being the world's largest glass container manufacturers. The other companies with a similarly broad range of products are Vitro of Mexico, Şişecam of Turkey, PLM of Sweden and Taiwan Glass industries.

Although, virtually all sectors of the glass industry follow the same pattern of geographical growth, the challenges facing the various parts of the industry are very different. Whilst there are no other materials, which can realistically replace glass in flat glass applications and in lighting industry, packaging glass is under cutthroat competition with the alternative materials, especially PET. The thesis focuses on this packaging glass playing in a competitive arena, therefore specifics of this sector will be explained in this chapter.

2.2.1 Container Glass

Glass is a traditional packaging material and one that shows the least change in the modern era, mainly consisting of glass containers used in the soft drinks, beer, wine and spirits, food, medical, chemical and dairy industries.

Regional supply is a feature of the container glass sector as transportation costs are high enough to restrict most suppliers to their region of manufacture. On the other side high cost of glasswork construction is a barrier to entry. Only some giant producers have managed to operate in the worldwide market.

Although showing relatively stable production trends, last few years, changed container glass' end user market considerably. With the advent of PET bottles and popularity of metal cans for both alcoholic and non-alcoholic drinks, share of glass has been diminished considerably in some sectors. Loosing share in packaging market and facing serious threat from the substitutive, glass turns out to be package for value added products in Europe and America. Meanwhile in a number of Asian and East European countries, glass continues to be the major pack for high volume soft drinks, the area in which it has suffered mainly in Western countries.

The main advantages of glass containers over other types of containers are that, they are easy to recycle, have good gas barrier and storage properties. The ability to offer variations in design and color also provides additional advantages and they are commonly used to make a product look distinctive. The disadvantages on the other hand are more obvious: despite considerable efforts in light weighting, they are heavier than the other forms of containers and are breakable, although for some products weight of glass represents high quality, especially wine and champagne.

PET bottles have been the main challenger to glass containers in the soft drinks industry, particularly glass containers in the carbonated beverage sector. However, because of its higher chemical durability and lower porosity, glass packaging is less likely to react with its content and is less susceptible to external gases than PET. The reasons for PET take over from glass are mainly to do with cost. Glass is more expensive than PET. The weight and fragility of glass is another major draw back. Besides, PET bottles can be easily shaped, manufactured in large sizes, differentiated and now like glass can be hot filled. Within this frame, world's packaging distribution according to materials is given in Figure 2.2 by 1995.

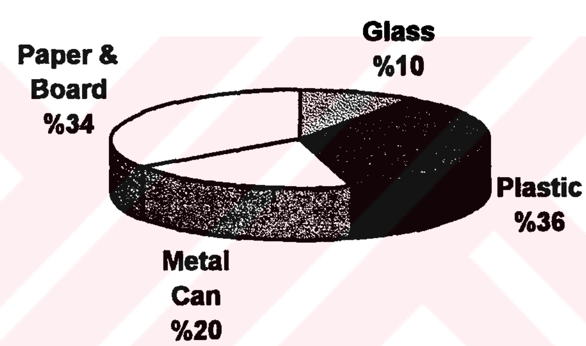

Figure 2-2 World Packaging Market by Material 1995 (World Glass File 1997, p:28)

World glass container production on the other hand is estimated at around 50 million tonnes. As it was stated previously, container glass is a highly regional product. Therefore to state distribution by region is meaningful (Figure 2.3).

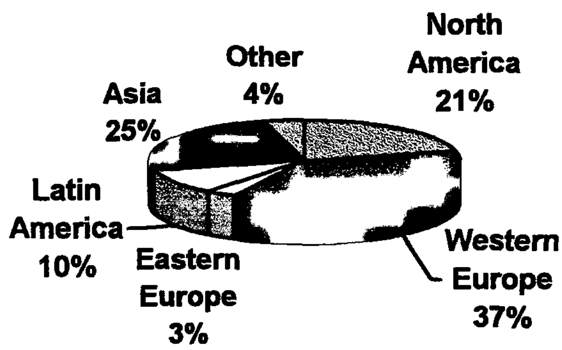

Figure 2-3 World glass container production;1997 (% volume) (World Glass File 1999, p:42)

Aggressive acquisitions and mergers are on going with several companies moving towards consolidation in a bid to increase competitive power in the container glass market. The market can be defined as lead by oligopolists, most of them being natural monopolists in their regions. By 1999 sales terms, the top container glass producers in the world are given in Table 2.1.

As Turkish container glass industry is used in the model, Western Europe needs a further analysis as the region of the actor in the model. Glass production by countries in Western Europe, between years 1994 – 1998 is given in Table 2.2. Turkey's rank is 8 here.

Table 2-1
Leading glass container producers, 1999

Company	Country	1998 Glass Container Sales (US$ Million)
Owens-Illinois	US	3,809.9
Saint Gobain	France	3,765.9
Consumer's Packaging	Canada	1,385.8
Danone[2]	France	1,027.7
Gerresheimer Glas	Germany	919.1
Vitro	Mexico	801.3
PLM (Rexam)	Sweden	443.0
Nippon Yamamura Glass	Japan	578.6
Toyo Glass	Japan	400.0
Heye Glass	Germany	224.7
Bormioli Rocco[3]	Italy	303.6
Ishizuka Glass[4]	Japan	192.0

Source:World Glass File 1999, p:43

[2] In August Danone and Gerresheimer Glass AG announced the merge of their glass container business. The new entity is comprised of all the glass container activities of Danone and the food and beverage container activities of Gerresheimer.
[3] 1997 figure
[4] Year ending 31.03.1998

Table 2-2
Western Europe: Glass container production per country, 1994-1998

(Tonnes)	1994	1995	1996	1997	1998	% change 1994-1998
Germany	4,430,245	4,578,596	4,506,156	4,293,693	4,323,180	(2.4)
France	3,315,308	3,487,333	3,516,050	3,642,322	3,785,142	14.7
Italy	2,862,868	2,909,427	2,918,400	2,929,182	3,046,948	6.4
UK	1,786520	1,885,542	1,966,767	1,969,600	1,852,100	3.7
Spain	1,373862	1,488,930	1,683,907	1,684,208	1,816,151	32.2
B+DK+IRL +NL	1,325,442	1,353,845	1,436,426	1,447,710	1,501,154	13.3
Portugal	645,034	668,250	742,517	751,221	762,977	1.6
Turkey	298,601	319,304	377,498	449,840	469,200	57.1
Austria	314,880	304,677	318,915	307,294	306,081	(2.8)
N+S+F	234,082	244,302	270,583	268,370	245,993	5.1
Switzerland	172,558	181,601	176,738	166,177	158,041	(8.4)
Greece	85,100	93,300	94,000	92,500	95,000	11.6
Total	**16,844,500**	**17,515,107**	**18,007,957**	**18,002,117**	**18,361,967**	**9.0**

Source: World Glass File 1999, p:45

Turkey's share from Table 2.2 can easily be calculated to be around 2.6% by 1998. World glass container production data for the year 1997 and estimates for 2001 are given in Appendix I. Market Share of Turkey in container glass production in the world in 1997 can be calculated as 0.9%. Although Şişecam, Turkish glass producer's share in the container glass market is low, in terms of over all glass production (including the other types, flat glass, table ware, special glass), Şişecam has a higher share in European and world market. The group claims a 1.4% share in global glass production and is the sixth largest glass manufacturing enterprise in Europe and 16th in the world.

Table 2.2 can be analysed by means of the growth rates as well, as in Figure 2.4. As it can be detested by the bold line, Turkey is 3rd fast growing market in Western Europe in glass container business, following Greece and Spain. Significant increase production was made between 1994 and 1997 in parallel with the other producers in Western Europe, afterwards, the capacity is almost constant.

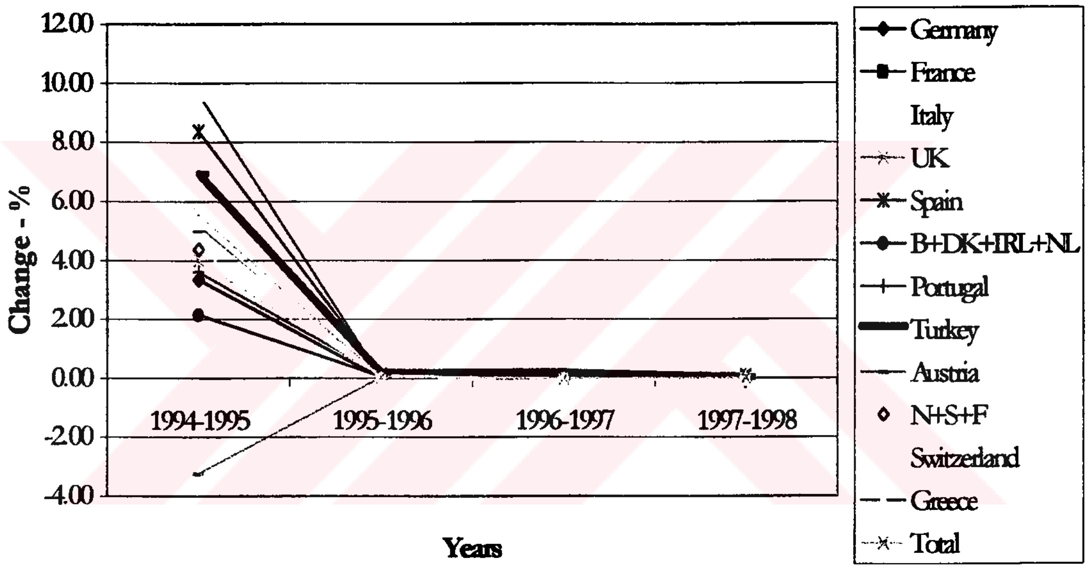

Figure 2-4 Growth rate of container glass production in Western Europe countries.

Synchronous investment in the market stimulates competition between glass suppliers themselves, besides the other packing materials like PET and metal can. The trade balance of countries in Western Europe is stated in Table 2.3.

Table 2-3

Western Europe: Glass container trade balance, 1997

(Tonnes)	**Imports**	**Exports**	**Trade Balance**
France	925,517	513,045	(412,472)
B+DK+IRL+NL	602,087	530,000	(72,087)
Germany	281,517	854,447	571,930
Italy	207,609	400,595	192,986
UK	126,236	143,321	17,085
Greece	102,223	10,830	(91,393)
Portugal	17,534	270,947	253,413
Spain	200,000	139,146	(60,854)
N+S+F	91,819	110,239	18,420
Switzerland	67,571	142,462	74,891
Austria	113,400	33,100	(80,300)
Turkey	600	55,500	54,900
Total	**2,736,113**	**3,203,631**	**467,518**

Source: World Glass File 1999, p:45

On the demand side of the market, drinks industry accounts for 77% of the glass container market. Food, cosmetics and pharmaceutical industries follow drinks sector. Shares of consuming sectors are given Figure 2.5.

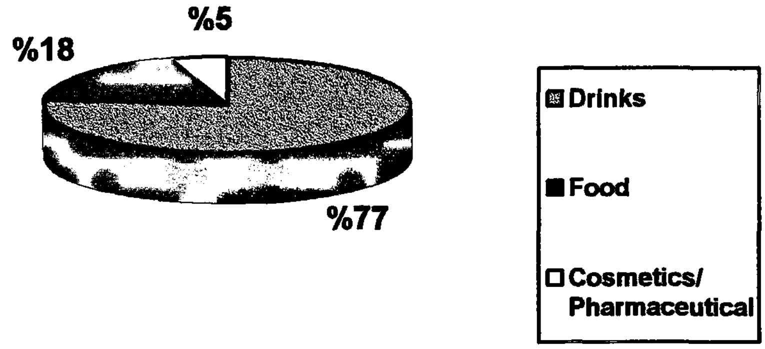

Figure 2-5 Western Europe Glass Container Market by End-user Sector 1997, Source: World Glass File 1999, p:47

Generally, in the drinks sector, the most stable end-user markets for packaging glass are the vine and spirits sector, where substitution by other materials has been very limited. In the soft drink and mineral water sectors, however, PET is substituting glass at an alarming rate. It can easily be said that, glass is about to be wiped out of market in soft drink sector. By 1997 figures, the PET share in the volume filled was 62% and metal can, 16%. Beer is the most critical sector after mineral water. Continued technical development in petro-chemical industry solves PET's problems as a packaging material and the weight and cost advantage it brings, helps to get the market. PET got 48.5% of mineral water market by 1996 figures and the next enlargement area is shown to be beer sector. (World Glass File 1997, p:49-52)

It is the growth in the light weight glass for value added glass products, along with advancements in various decorating, coating and coloring techniques that has allowed glass packaging to maintain its share of the overall European packaging market at 10% by value and around 30% by volume.

Glass Packaging has not seen any major technological changes in recent years, although there are some minor developments, like light weighting and recycling. For the non-returnable bottles especially, between 1970 and 1990 weights are reduced up to 40%, keeping the strength of the bottle same. Concentrations of technological efforts in the last years in glass sector are briefly explained in Appendix II.

2.2.2 Turkish Glass Sector

The glass industry in Turkey is dominated by Şişecam or Türkiye Şişe ve Cam Fabrikaları A.Ş. (TŞCFAŞ), which is among the most fully integrated glass producers in the world, producing flat glass, glass fibre, glass packaging, table ware, glass oven and glass tiles with the state of the art technology. Share of each division in the capacity of Şişecam is given in Figure 2.6, by tonnage terms.

The company also owns business associated with the excavation of raw materials and production of glass making tools and machinery. Şişecam group is made up of the holding company and its subsidiaries comprising 33 companies. The shares of TŞCFAŞ have been publicly quoted at the İstanbul Stock Exchange for over 13 years, but Türkiye İş Bank, one of the largest financial organisations in the country, kept a controlling interest and currently owns around 75% of its capital.

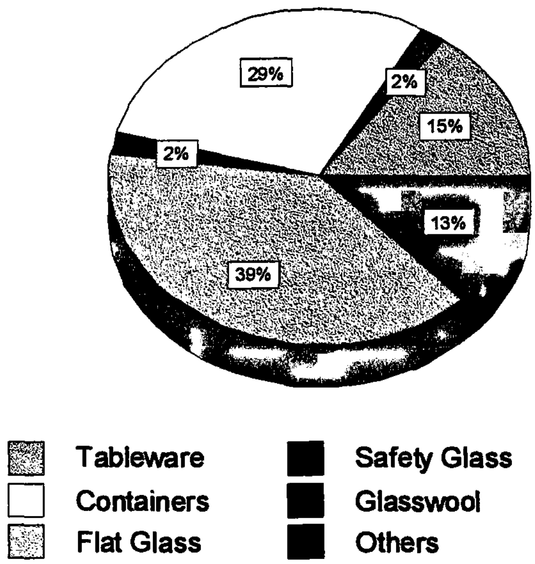

Figure 2-6 Share of each division in Şişecam's over all glass production capacity (by tonnage terms)

It can be said that the group is vertical integration of companies engaged in many of the critical activities of glass production. The chemicals division principally manufactures soda ash, one of the most important inputs of glass. In soda ash manufacturing, Şişecam ranks among the 10 largest in the world, with an annual capacity of 1.1 million tonnes. Division is also active in production of Chromium chemicals and glass fibre. Suffering from electricity interruption in the country for a long time, which is also critical for continuous production, the company established powerhouses near the plants.

The company's packaging operations consist mainly of the manufacture of glass bottles and jars for the food and beverage industries. Containers are manufactured by two group companies in Turkey, Topkapı Şişe Sanayii A.Ş., which has production facilities in İstanbul and Çayırova (Since 1995) and Anadolu Cam Sanayii A.Ş.[5] located in Mersin, with a capacity of 1600 tonnes per day in 25 lines.[6] (In 2000, Topkapı Şişe San. A.Ş. was taken over by Anadolu Cam San. A.Ş.) In 1997, Şişecam acquired 76% of the stocks of the glass packaging plant in Ksani, Georgia to serve the market in Caucasus.

Şişecam accounts for more than 80% of Turkey's glass container production. The remainder represents the small amount of import and the pharmaceutical ampoules and vials, which are not currently produced in Şişecam facilities. In most of the sectors connected with the Turkish glass container industry, demand is increasing at a rate of about 5% per year. Currently Turkey operates a comfortable trade surplus in glass container sector as well as other glass products, with the exception of speciality glass. In container glass sector by year 1997, export was around US$ 20.718.000, where import was US$ 8.503.000, giving a positive balance of US$ 12,215,000.[7] In year 1999, export was around, US$ 25.000.000, accounting more than 10% of total sales.[8]

Şişecam sources almost half of its machinery from Heye Glas, Germany, with which it had technical assistance agreements for a number of years. Future Plans in Şişecam are to concentrate on lightweight bottles and on flacconage. Most of the production will be targeted at the domestic market, and around 15-20%, export.

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[5] During 1997 capacity expansion and improvements were completed at one of the furnaces of Anadolu Cam and a brand new plant equipped with state of the art technology was put in to operation.

[6] In year 2000, one of the furnaces in Topkapı Şişe Sanayii Topkapı Plant was closed with the 4 connected production lines. Therefore production capacity decreased to 1400 tonnes per day with 21 lines

[7] Until January 1990, imports of glass products into Turkey had been negligible because of the high import tariffs as of that date, forced the Turkish glass industry to become more competitive. In order to cope with the difficult trading situation, the sector has had to undertake radical restructuring measures. A total of US$ 485 million by 1996 was spent to upgrade and expand the facilities.

[8] Annual Report of Şişecam - 1999

2.3 STRUCTURAL FEATURES OF GLASS MANUFACTURING

To explain economic and technical features of glass manufacturing is essential before going in to the market conditions and its result, tendency of innovation, as these features form the basis behind the actual structure of market and the structure of firms. The economic features that will be explained later are simply natural results and reflections of the technical features, on firms' policies.

Main inputs of glass manufacturing, characteristics and essentials of production will be referred in Technical features. Summaries on Investment decisions, break-even points, structure of firms will form economic features and these will be discussed in detail in the next chapter. Information used here, are collected from the Technical Bulletin of Türkiye Şişe ve Cam Fabrikaları A.Ş. – *Main Principles of Glass Technology* and Glass Sector Report of Yakup Incesu (1996).

2.3.1 Technical Features

Main raw materials of glass are sand, soda, dolomite and feldspar. Continuous supply of these materials with steady compositions is quite important for the control of glass quality. Glass producers that are close to the raw material resources have competitive advantage over the others. To keep the chemical composition of these materials steady, a series of processes are necessary to apply before usage. All of these are costly processes and of absolute necessity to compete in the global market with high quality glass. In this regard, Turkish glass industry is vertically integrated, which means, the raw materials needed by the industry is produced by the firms in the same group, to get rid of any critical problem that may arise due to the inconsistency in raw material. Turkish market share in soda production is 1,7% in the world and 10% in

EU.

One of the most distinguishing features of the glass manufacturing is its nature of energy intensive production, based on high temperature melting technology. Raw materials are mixed according to the recipe, namely the batch is prepared and fed to the glass melting furnaces. The maximum temperature is 1500 - 1600 ^{0}C in the furnaces, where the raw materials are melted. These furnaces are to be kept hot all along their campaign period for 7-10 years. Even controlled cool down creates residual stresses on the refractories of the furnaces, which may result with the loss in the furnace life. That is why after heating glass furnaces up, it will be preferable to keep the furnace hot even if no glass is produced. In this case which is defined as loadless fuel consumption, energy consumption is approximately 45-50% of the normal in a modern furnace. So to reduce the marginal energy consumption in this sector, working with full capacity is of vital importance, as energy is the second important cost criteria after raw material. The share of energy in the total industrial cost changes between 15-20%, although it depends on the type of glass being produced. By isolation and other means, glass producers aim effective use of energy. Cullet usage reduces the energy consumption by 1% for extra 5% in batch as well as its importance for environmental reasons, highlighting the importance of glass recycling and cullet collection.

Because melting technology requires keeping the furnace hot continuously, and because the break-even point of the sector is quite high, due to excessive energy intensity of production; continuity is necessary to reduce the marginal costs. With continuous production, glass producers aim to meet the changing demand conditions with diversified types of products, which necessitate elasticity in production.

Another limiting factor for plant capacity, besides the glass melting furnaces is the capacity of the shaping machines and the annealing lehrs. If the capacity of the equipment does not match with the furnace capacity, efficiency of the furnace falls. Due to the continuous innovations in technology, although the technical life of the equipment is not half finished, it may be subjected to change, to be able to compete in the market. This situation brought the uninterrupted investment requirement with itself.

Continuous investment requirement in glass sector is both due to the global economical and technological development dynamics and to the melting technology it employs. Furnace repair, modernization of the shaping machines and equipment, renovation of the supportive service equipment, improvement in measurement and control instruments, etc. which affects the competitive power shows that, glass industry is capital intensive as well as energy intensive.

Main importance being in the developments in shaping machines and concerning equipment, quality standards of the raw materials, new designs in melting furnaces, heat isolation, secondary processes like coating, decoration technologies are of great importance in the investment programs.

In the glass sectors, instead of technical life of the machines and equipment competing life are of consideration in the recent years. Besides, with the globalization rapid changes in demand brings the requirement of process technology forward in the agenda.

As it is in most of the developing countries, per capita glass consumption in Turkey is less with respect to the developed ones. But the acceleration of the increase in consumption is relatively high. The growing rate in glass sector in developed countries is 2-4% while 7-8 % in Turkey. To keep the growth continuing, investment is the most important factor.

In glass sector, most of the technological R&D activities are concentrated on the energy efficient furnace design technology and process effective technologies and especially for container glass, light weight products. The R&D activities, which have other dimensions then technology, like client supportive services gained importance in glass sector as well like many others.

Improving the competitive power of the glass producer companies heavily depends on technology creating activity instead of transferring. Technological improvement, with the increased efficiency and reduced costs, gives rise to new products with high value added where this plays the major role in increasing the market share and competitive power in domestically and worldwide.

As it is the case in all of the industries depending on the melting technology, macro-economic policies are of great importance in glass sector. Decrease in demand due to these policies or strikes may cause the stocks to expand, so the costs to increase astronomically. Either at the production stage or post production, additional costs, being a function of the country infrastructure, which is an independent variable of the firm, should be considered in competition analysis.

In considering the free and fair market conditions, beginning from the consistency in energy supply, the structure of the railways, harbors, education system, communication system, etc. are all highly effective in determining the competitive structure of the countries. For example, the developed railway system in West Europe is in favor of some glass producers like Heye and Flach glass, even coming to the plants, where Turkish glass producer lacks such a system, which increases the transportation costs especially for raw materials. Energy supply is another dimension of the issue; in most of the European countries, energy costs are considerably less with respect to Turkey, which is of great importance for glass sector. Where in Turkey, besides high costs, electricity interruption is one of the most critical cost issues, on the average reaching 3% production loss annually. In most of the European countries, recyclability of glass being the top priority against the substitutive, is highlighted and cullet collection system is well established. Cullet usage reduces the production costs considerably, but the percentage of cullet in batch in Turkey, is around 25%, where almost 100% is achieved in some of the European countries.

Glass industry in our country, tries to find solutions to the infrastructure problems in Turkey, by increasing its integration. Inputs like mould, packaging, soda, sand, gypsum, dolomite and the services like transportation are among the activities of this sector, while having some disadvantages comparing to the foreign competitors.

The productivity of employees in the developed countries, having technical schools for intermediate personnel and glass specific schools, are considerably higher than in Turkey. This lack of education is to be compensated by at work training in Turkish glass sector.

After the GATT regulations, which removed the customs tariffs and quotas, the technology based sectors are began to be protected by subsidies like R&D. This kind of a system is also among the deficiencies of Turkey. Lack of implementation of the measures came with the 1989 anti-damping regulation to Turkey, is also an important factor ruining Turkish glass industry. While EU producers are heavily protected against damping, glass industry in our country faces with the damping threat coming from the Eastern Bloc countries. Since 1989, this regulation is the only tool of protection for this sector, if it is run systematically.

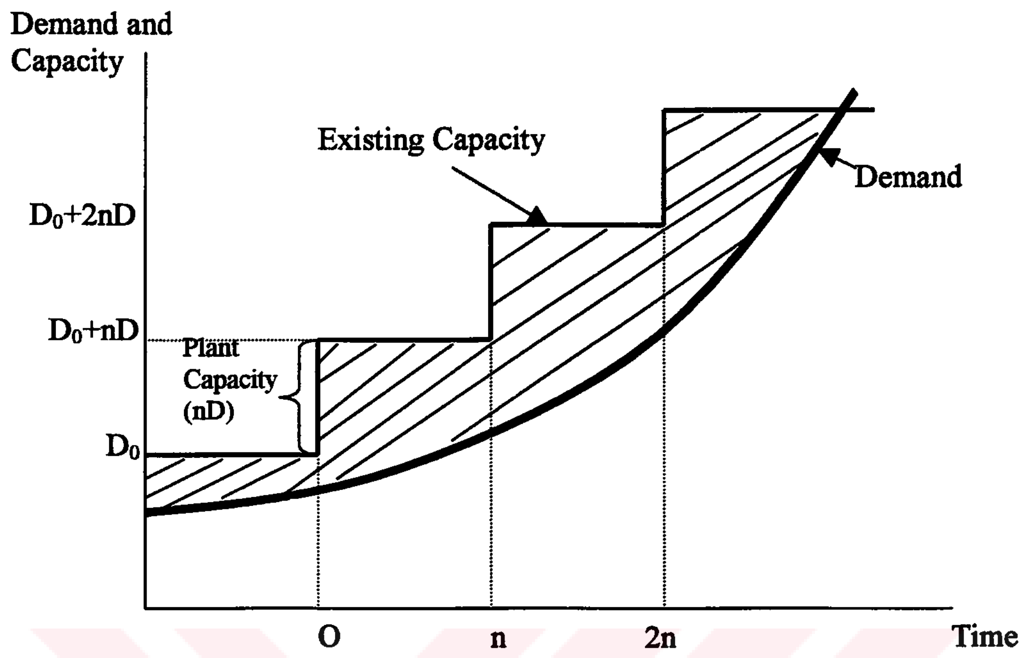
Code of "Technical barriers against trade " of GATT, should be applied in Turkey as well; to protect the industry from infringement of patent rights. This point is of major importance especially for tableware, to prevent the import of low quality and copied products especially from the countries out of EU and EFTA. Thus in order trade to be equally profitable to each party, similarity in socio-politic, economic conditions and regulations of foreign trade is highly important.

A production can be defined as elastic, if the machines are of modular characteristics, convenient for stop-run up, the technology is of divisible nature; namely, if the capacity is elastic. Melting based technology as explained above has some technical and economic problems in front of stopping production. Besides it has an indivisible nature. For this reason designing small furnaces with low capacity to create elasticity to some extent is not valid for all types of glass, because of the economy of high capacity. Although packaging, decoration and stocking policies are considered as tools to solve this problem out, compared with other production sectors, where production can be stopped, this sector is highly inelastic.

2.3.2 Economic Features

In glass sector, the factors, which force the scale economy, are its energy-based nature and the requirement for continuous production. A furnace with less capacity then 300 tonnes/day for flat glass, 280 tonnes/day for packaging glass and 100-120 tonnes/day for tableware are not considered to be feasible. Large furnaces are more economic then small ones because, less surface area means less energy loss. For this reason all around the world, capacities of glass furnaces are increasing rapidly.

Besides, in order to keep the leadership in glass sector in any country or region, supply should exceed demand. Supply increases stage by stage in glass sector. In Figure 2.7, typical supply characteristic of Turkish glass producer is given. Shaded region is the supply beyond the demand, so exportable amount.



D : Annual increase in demand

n : Time passed between the building of two different plants

nD: Annual capacity of the plant

Figure 2-7 Changes in demand and constructed capacity with time

Due to this nature, following the investment period, it becomes necessary for glass producers to work with P=MC, because of increase in competition.

Policies considering demand first then supply is not valid in this sector, because it drives the domestic and foreign entrants in to the sector. In this manner, above-mentioned policy has a deterrent effect for entrants as well.

Because the sector is based on scale economy, market has an oligopolistic nature. Uncertainty, not only about the market conditions, but also about the activities and policies of the competitors makes a strong strategic planning management essential.

Vertical integration means the chain beginning from the raw material, till the product reaches the end customer is under the control of same firm. There are some advantages and disadvantages for such firms. The reason for glass sector to establish a vertical integration is due to the inability of supplying raw material of adequate quality. Besides, an integrated structure also has a dissuasive effect on potential entrants. Turkish glass sector has both vertically and horizontally integrated structures, which means obtaining product variety in the production process. This kind of structure leaves the glass producer companies in difficult positions especially during the economical crises. The sector is wholly shocked during these periods. For this reason, elasticity of the hard integration structures is to be decreased.

In glass sector, because the production is both technology and capital intensive, first investment cost is considerably higher, where profit margin is lower than the other sectors. Necessity of employing high technology in the melting process, an uninterrupted production, need of harmonization in the post furnace processes, which is abundant, are some of the reasons.

For this cost reason, and due to the vertical and horizontal mergers in the sector, enter and exit barriers to the sector are considerably high. Market share of the top ten glass producers worldwide is 80 %. Glass sector, being an oligopolistic market worldwide, generally has a monopolistic nature in the countries for domestic markets. Thus, competition should be perceived internationally. In this frame strategic trade policies of the governments play the key role in determining the competitive power of the glass producer firms in the world.

Break-even point is the point where total revenue equals total cost. Although it depends on the type of glass being produced, the break-even point is around 75% of the capacity (İncesu, 1996,30). This restricts the entries and exits of the sector, increases the risk factor and contributes to the oligopolistic nature to be formed. Profitability of the sector as referred above depends on both continuous and full capacity production. Besides as reliability of production, distribution and client potential are as well of high importance. To satisfy these, producer firms sometimes sell the excess capacity by damping to search alternative markets in the world. This brings the anti-damping regulations in to agenda, which is among the new protection policies.

As explained above strikes, slowing the production down, mismanagement and recession in demand due to macro economic policies has destructive effects on this sector, like many other sectors based on melting technology.

Due to the structure, there are a few dominant firms in glass sector worldwide. In addition to this the decrease in profits, even under critical values in the last years, make the tendency of oligopolism. This nature eases the price determination in the sector. The low profit profile, mergers, cost of technological innovations and cost of investment are among the natural and artificial reasons that make the concentration high.

Quality of glass products does not change considerably firm to firm and the products are also of global characteristics, does not have a distinctive property. The only draw back from these priorities is in glass container, where the transportation is a barrier. In general price elasticity of demand is relatively higher. With this structure glass sector is an internationally competitive sector. As a matter of these facts, 80% of glass production is in the hands of 10 firms in the world. In Turkey, the glass producer, being among the world's top 10, is a monopolist in domestic market, as many of the above-referred big firms.

The requirement of continuous production with full capacity, where high capacities are more profitable, gives rise to sales under marginal cost, namely damping. If the enlargement of capacity meets with the other producers in the market, the due excess supply increases the competition, which decreases the profits in the sector. Producers find damping as a remedy both to find new markets, and to hinder the potential entrants. One of the most important effects of stage by the break-even point around 75% of the capacity is also among the reasons of the damping sales, which are widespread in glass sector.

Having explained the sector specifics, in the next chapter, theory of market classifications will be presented with reference to these features of container glass industry before research and development theory, as it is the market conditions, the motive behind development activities.

3. DEFINING MARKETS and CATEGORIES OF COMPETITION

The two major aspects of market economy, product type and geographic area are of critical importance and this chapter will be dedicated to how these two shape the container glass market.

The key condition in defining a market is said to be the *substitutability* by Shephard (1990, p: 54). Substitutability can be expressed by cross elasticity of demand, which is a measure of how sharply a price change for one product, will cause the quantity sold of other product to change.

$$\text{Cross elasticity of demand} = \frac{\text{\% change in quantity of good A}}{\text{\% change in price of good B}}$$

This phenomenon also affects the geographic market areas. In case goods A and B are identical goods, and if the price in region 1 affects the price in region 2, then the two regions are in the same market. Otherwise, they are separate. The geographic extent of the market, is indicated by the size of the cost of transportation of the goods in question, compared to the value of the good. The feasibility of transporting the good from point A to B determines the borders of the market.

Evaluating glass container market from this perspective, a regionalized product is faced with. Glass is neither feasible nor safe to be transported in the form of large volume containers, as it is fragile, heavy and occupies large space. Therefore transportation barriers in general, naturally protect local glass industries from far away competition. Combination of this barrier with other factors, which will be detailed later in this chapter, creates natural monopolies. However, container glass market faces cutthroat competition from substitutive goods like PET, carton box and metal can in some market sectors[1].

Glass containers are consumed by many industrial sectors like Pharmaceutical, beverage, wine, champagne, beer, water, mineral water, and food. Market characteristics in terms of substitution for each of this fragmentation should separately be dealt. For wine and champagne industry for example, container glass is the sole type of container, without any alternative. For beverage and fruit juice industries on the other hand, PET, carton and metal can substitutes glass container year by year. Although cross elasticity of demand is not very easy to be determined accurately as it is affected by time and product features; beverage industry may be a good example for high cross elasticity of demand between glass containers, PET and metal can. Over million liters of carbonated beverage consumed share of container glass was reported to be around 30,7% in 1995, but decreased to 12% in 1998[2]. Excess supply of PET resin between these years lowered the PET prices and high cross elasticity of demand between PET and glass container for these sectors, caused glass to loose market.

Major determinants of cross elasticity of demand for other market sectors are the natural properties of substitutive containers, glass and the consumer industries' needs and strategies. PET can be regarded as a substitute of glass containers for high volume consumption materials. However, for the markets focused on niche products, long shelf life and gas permeability, glass is superior to alternative materials, and can not be abandoned.

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[1] Beverage industry uses PET, metal can and glass bottles, fruit juice and milk industries use carton box and glass. In all these sectors, glass looses market share year by year.

[2] Canadian Limited's "Beverage Packaging Service, Turkey, 1999".

Cross elasticity concept is also valid on the supply side of the market to refer to the ability of producers, which are out of the market for some good to switch their capacity from other goods to the good in question. It should be stated that, container glass industry is protected in this manner as well. Glass production technology in general is highly specific, requiring high levels of investment and knowledge accumulation. The inelastic nature of production is another drawback for any potential entry decision. On the other hand, for the players in the container market, PET resin and metal can production are quite different technologies, although they substitute glass well in many sectors. To switch between any two, necessitates significant sunk and first investment costs.

Within this framework, conditions of competition and market models of container glass market, Turkish container glass market being in focus, will be analyzed in further detail to be a basis for the past and future motives behind the technological activity in Turkish glass sector.

3.1 COMPETITION ISSUES IN GLASS CONTAINER MARKET

Market power can be defined as the ability to influence price or output in the market place. (Martin,1994, p:228) Any firm that has the ability to set price above marginal cost, the perfectly competitive equilibrium price, is said to have market power. Market power increases with increasing concentration and with difficulty of entering the market, in line, is an element of market structure. Economists differ fundamentally over the nature of the conditions that determine market structure. The "Structure Conduct Performance" framework holds that, the technology and strategic behavior of existing firms in the market affect market concentration, therefore structure. Bain proposed that product differentiation and economies of scale make entry more difficult, and combination of this with concentration in the market, increases market power, creating persistent high profits. On the other hand, Chicago School suggests that market structure reflect the efficiency. If the market is concentrated, it is because efficiency is achieved in that way. (Demsetz, 1974, p: 166-167)

Therefore it is evident that market share is the most respectable indicator of firm's power to affect the conditions of market. The share of the firm in the industry's total sales determines firm's market share. Degree of market power usually accepted to occur at 15% market share. (Shephard, 1990, p: 62)

Using market share, "Lerner index", or "monopoly markup" is defined to measure degree of market power as;

$$\frac{P - MC}{P} = \frac{s_i}{\varepsilon_{QP}} \qquad \textbf{(3. 1)}$$

s_i = market share of firm i

ε_{QP} = price elasticity of demand

Market share is widely established in business as a focus of company's motives and strategies. Price elasticity of demand as well, besides market share is important to exercise market power, as it reflects the sensitivity of price to change in output. If the quantity demanded is very sensitive to price, the price elasticity of demand will be large, and the right hand side of the Equation (3.1) will be small, which makes the profit maximising price close to marginal cost, similar to the competitive model. On the other hand, if the price elasticity of demand is small, the firm will be more effective on increasing the prices above marginal cost, without suffering any substantial loss. In case of import threat, marginal cost should be checked with transportation costs of competitor and which ever the lower, should be used as determination criteria of price. It indicates that, even a monopolist may have limited market power, if the price elasticity of demand is high. A less elastic demand curve will result in a higher monopoly mark-up. Almost all container glass suppliers enjoy low elasticity, nearly rigid demand curves for the consumer sectors like serum, wine, champagne, beer and other alcoholic products, being the suppliers of the sole type of container. On the other hand, faces with highly elastic demand curves in beverage, fruit juice and milky products, in competition with PET, carton box and metal can.

As price elasticity of demand is given, market share appears as a measure of success of firms, being the source of profits. Rate of return for an investment increases proportionally with market share. As it was stated before, the world giants of glass container market have nearly hundred per cent share in their domestic markets. However, if the domestic market is concentrated on, for some of the consumer industries[3], market can be regarded as container market, where share of glass, therefore the monopolist goes down year by year; anyway still an upstanding market share is there. On the other hand, for the alcoholic drinks sector[4], which glass is the sole container material, the monopolist container glass producer has almost hundred percent market share in its domestic market, being protected by the transportation barrier as well, enjoys dominancy. That is to say, whichever market is dealt with global or domestic, container glass market is highly concentrated.

Concentration, the combined market shares of the leader firms, can be briefly defined as the degree of oligopoly. Oligopolists have the chance to coordinate the market, as if they are monopolists. But this depends on the internal structure of the oligopoly. They may pursue policies in conspiracy, or fight or ignore the others. In order to measure which one is more probable and how competitive the industry is,

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[3] Beverage, fruit juice and milk

[4] Wine, champagne, beer, other alcoholic drinks, serum, etc.

concentration indices are defined. The State Institute of Statistics conducts reports for each industrial sector, which gives the market shares of the largest 4 firms, the largest 8 firms, the largest 20 firms and the largest 50 firms in each sector.

$$\mathbf{CRN} = \sum_{i=1}^{N} s_i$$

s_i = market share of firm i.

These ratios are used as a measure of the fewness of the suppliers in the market. Although the thresholds may change, when the largest four firms in an industry together supply 40 percent of the sales, then this industry can be treated as an oligopolistic industry. These are called N firm concentration ratio.

Such concentration ratios provide a limited information about the sizes of the largest firms. For example, a four-firm concentration ratio of 50 percent could mean, the largest firm owns 47 percent of the market and the other three only one percent. At the same time it could mean similar four firms with market shares 12-13 percent. These two examples require different analysis. For this reason, an alternative measure is sometimes used: Herfindahl-Hirschmann Index. This index has the merit of combining information about the market shares of all firms in the market. If there are N firms in the market, Herfindahl index (H) equals to the sum of the square of the market share of each firm.

$$\mathbf{HHI} = \sum_{i=1}^{N} s_i^2$$

As it can easily be seen if the market shares are equal, the Herfindahl index equals to 1/N and it will increase, as the concentration increases. This index can be used to estimate the number of equivalent firms in the market as well. Reciprocal of the HHI simply means the number of equivalent size firms in the market.

In glass sector, as they are monopolists mostly in their home countries, taking world market in to concentration for Herfindahl index would be more meaningful. Although market shares of all firms in the market is to be taken in to consideration to calculate the HHI, by neglecting the small shares' contribution, according to Table 2.1, HHI can be calculated as 0,1774, to represent the degree of oligopoly. This would have been around 0,0833 if the market had been equally distributed. Reciprocal of HHI is used to have an indicative measure for the number of equally sized firms in the market as well, in case the market had been equally distributed. In container glass sector case $1/0,1774 \approx 5$ is the number of corresponding equivalent firms.

3.2 STRUCTURAL APPROACH TO CONTAINER GLASS MARKET

Being an oligopolistic market globally, substitutive competition container glass faces, as mentioned before, makes the sector behave according to the consumption sector in question. The active firm in the sector has dominant power, protected by transportation barrier, in vine, champagne and spirits sectors. However, the substitutive competition in soft drinks and the global competition in pharmaceutical sectors (as transportation cost is relatively low and as the consuming sector's main concern is quality) cause the competition models of oligopolistic market to be valid.

The oligopolistic nature of the market (even in dominant firm case, as long as the market is contestable) forces the firms to non-price competition in the long run.

Price, the main tool of competition, comes to a stable point, either by gentlemen agreement or in a competitive way, then the players in the market prefer the non-price tools of competition. The non-price competition tools, namely the complementary tools of competition can be horizontal and vertical merger establishments, advertising, distribution to make goods easily accessible to clients, research and development for product differentiation and process innovation.

Concentration on the innovative activities, the core of this study is one of the most important of all these. The structure of the market forms the incentive behind such activities, and therefore is an important parameter here, for the strategic choice of the degree of innovative activities. Therefore, before analyzing the theory of Research and Development, the structure of container glass market needs to be focused from different perspectives, as it has an interesting nature, and an interesting combination of models.

3.2.1 Oligopolistic Approach

Between the two extreme market cases, monopoly and perfect competition, oligopoly may be considered as representing the practical markets. In monopolistic markets, if the entry costs are high, the dominant firm's power on market reaches its maximum. On the other hand, if entry costs are sufficiently low, exercise of market power will make the dominant firm, to loose market share, and at the end the market becomes oligopolistic. Considering the profit maximization technique of a monopolist, it can easily be deduced that, each firm in an oligopolistic market maximizes its own profit simply by collusion, namely acting with the other firms in the market as a monopolist.[5] Lower the number of firms in the market, easier the collusive behavior will take place.

There are many reasons for oligopoly, one and the most important for global glass industry being economies of scale. In some industries, low cost can not be achieved, unless the firm is producing an output equal to substantial percentage of the total available market, with the consequence that the number of firms will tend to be small, even only one. The maximum number of firms is determined by the relationship between "optimum size of firm" and "total market size". If optimum size of a firm is large relative to total market size, than only a few firms will be in the market. Figure 3.1 represents how optimum size can be determined.

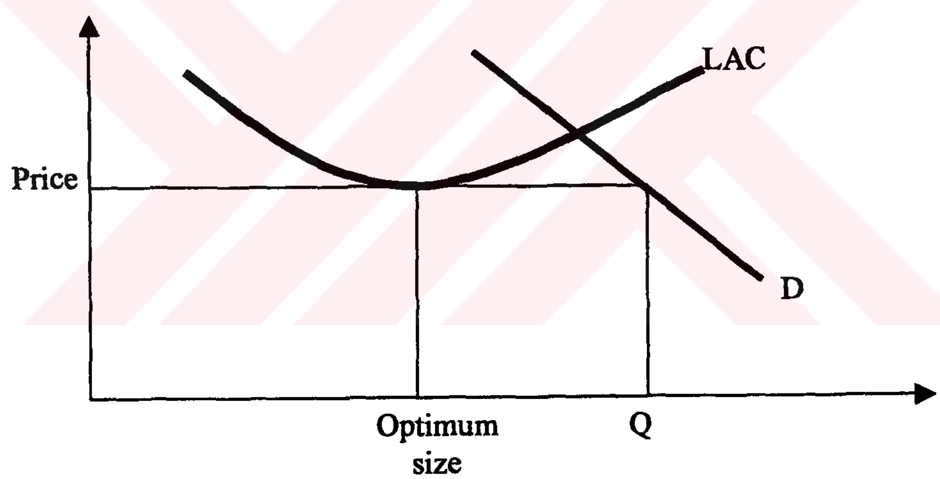

Figure 3-1 Maximum number of firms in a market

[5] Collusive behavior will occur as long as the long-run average and marginal cost of production are equal for firms of all relevant sizes, entry of new firms is free, demand for the output of the industry is stable and the specialised resources employed in the industry are indestructible. (See Stigler, G.J.; Monopoly and Competition Policy II)

Most of the industries based on melting technology can exemplify firms achieving optimum size with large capacities, like glass, cement, iron & steel industries; therefore these markets are generally oligopolistic, even monopolistic markets.

One of the models to analyze oligopoly is named as Cournot model, where, firms decide the quantity to produce, and let the market determine the price according to the total supply in the industry. According to this model, firms set a production schedule in advance, where changing this schedule, requires some sunk costs. (Martin, 1994, p:116)

Glass production in general may be treated in this category. Major trends in glass demand forecasts for 7-8 years[6], are used to determine the capacity of investment that is not flexible to make substantial variation. Considering the economies of scale principle, efficiency is achieved by full capacity production, causing glass industry to live excess supply, in the years just following the investment as represented in Figure 3.2 by “A”. Optimum level is reached at “C”; and supply falls short of demand just before the next investment “D”. Planning for next investment normally starts just before the optimum point shown by B, to be on time for start up.

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[6] Average life of a container glass furnace. As the shortest life belongs to the furnace among a glass production plant’s facilities, the other parts are generally designed with larger capacities sufficient to serve probable capacity increases of the furnace.

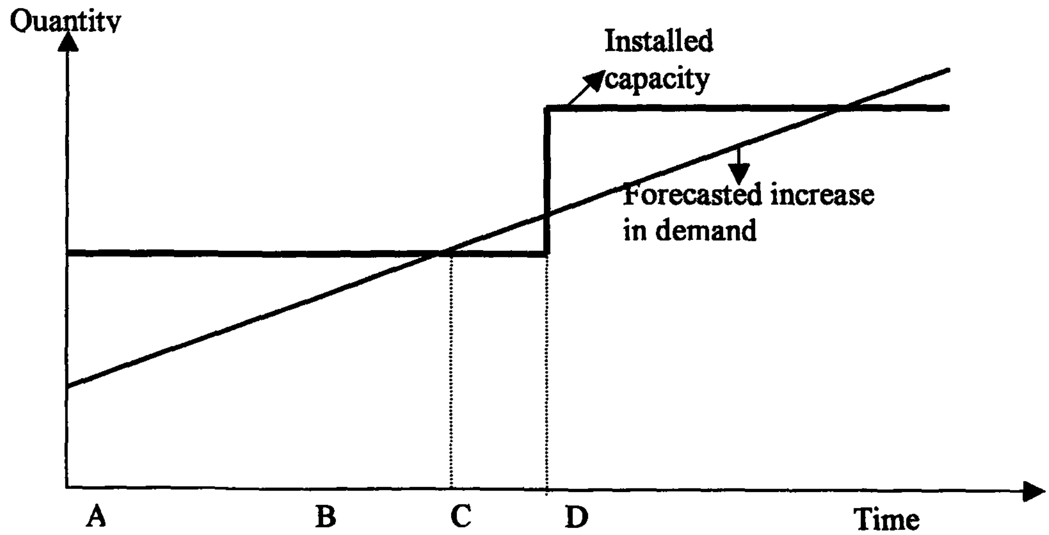

Figure 3-2 Typical investment point

Prices in the market also follow up this cycle; begin with low values, due to excess supply, and increase as demand increases. On the other hand stocks are vice versa. Swelling of stocks just after start up of new investment lets the supplier meet demand during the times supply falls short of.

This cycle is very important, especially in domestic market, as it is fully sensed by the domestic producer. In the world market, this peaks and troughs can be cut through, by phase differences between different producers. Therefore, timing of investment is determined according to domestic market needs, with a small margin for export.

After determining the level of investment, to reach an efficient production, running full capacity is the target for glass container producer. First goal is full satisfaction of domestic market and surrounding countries, to protect domestic market from import glass. Next goal is to sell the excess capacity planned as export margin, in the world market. As stated before, if in general the container market is concentrated on, for some consumer sectors, like wine, champagne, and almost for beer industry[7], glass producer is dominant. In parallel, especially for beverage, fruit juice and recently for mineral-water industries the quantity pre-determined, is to be sold in competition with PET, metal can and carton box producers[8]. Although, natural properties, cost structures of and consumer firms' strategy on these products are of great difference, namely the goods in question are heterogeneous, Cournot model for heterogeneous goods holds in this market.

3.2.1.1 Cournot Model

Cournot model is generally explained by examining a duopolistic market, supplied by identical firms, where it can be generalized to a market with more than two firms, which are not identical; even to a market of non-homogeneous goods. (Daughety, 1988, p:14-16).

3.2.1.1.1 Homogeneous Product Case

In Cournot model, the basic assumption is that, firms expect their rivals to maintain a constant output level. In Figure 3.3, the behavior of the first firm in the duopolistic

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[7] Metal can has a small market share, but dominating container is both refillable and non-refillable glass.

[8] For fruit juice industry, main competitor of glass is carton box; for carbonated beverages and mineral water PET with increasing share, for the last years. Metal can on the other side, has steady market share on the small volume fruit juice and carbonated beverages market.

market is given. The marginal cost is assumed to be a constant c, and fixed cost zero, so the marginal cost and the average cost curves coincide. If this first firm is thought as a potential entrant, then it will decide on its output by maximizing its profits, by equating the marginal cost curve to marginal revenue, along the residual demand curve, found by subtracting the constant output of firm 2 from the market demand curve. Therefore, the profit maximizing output of firm1 depends on the output of firm 2.

By changing firm 2's output level, reaction of firm 1 can be determined. If firm 2 produces nothing, then only firm 1 will supply to the market, so will determine its quantity as a monopolist. On the other hand, in order to keep firm 1 out of the market, firm 2 should supply all what is demanded at the price equal to marginal cost level, like competitive markets; otherwise, firm 1 will enter the market.

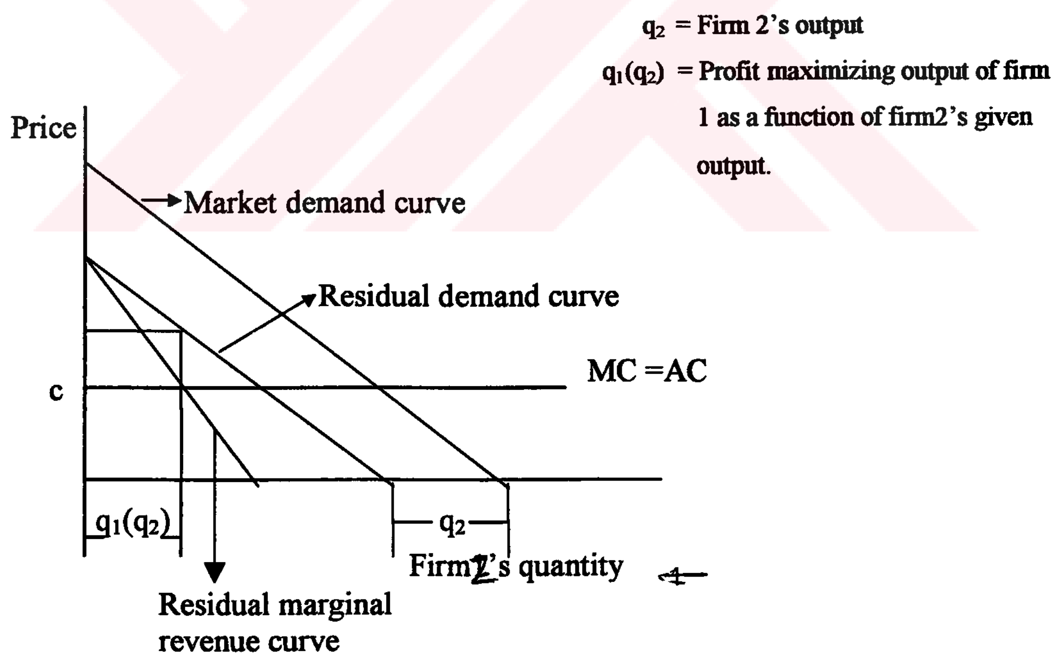

Figure 3-3 Firm1's output decision in quantity setting duopoly.

After the two end points are determined, the reaction curves can easily be drawn, because, if the market demand curve is a linear curve, the reaction will also be a linear one. (Fig.3.4)

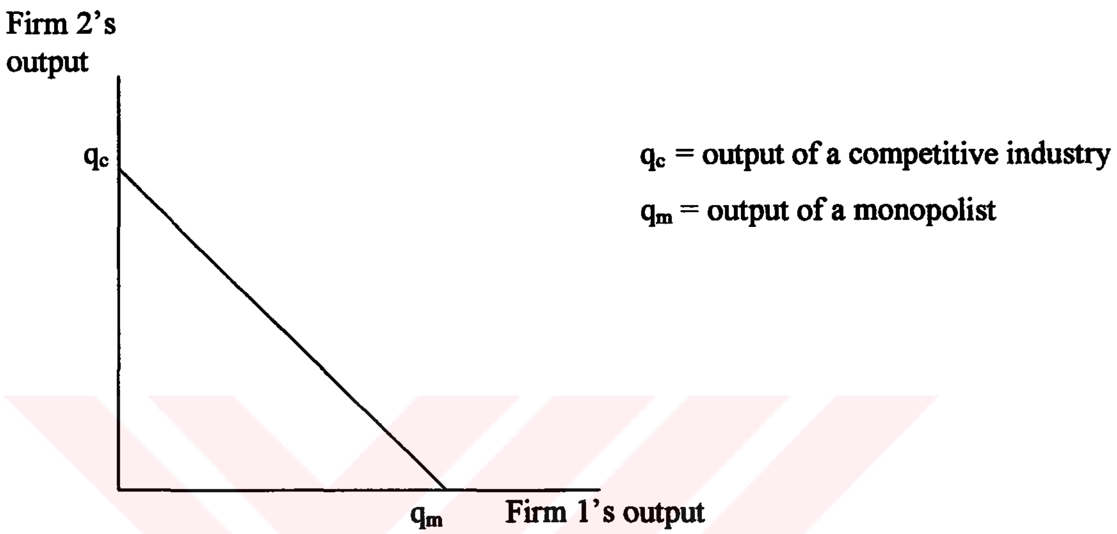

Figure 3-4 Firm 1's reaction curve.

By going through the same steps, the reaction function for firm 2 can also be driven. If these two curves are put on the same graph as in Figure 3.5, it can further be concluded that, such a market will come to equilibrium at the intersection point. Other points will be inconsistent and with experience, will drive the firms to the intersection point. At the equilibrium point, neither firm changes its output, which is profit maximizing, given what it believes the other will do.

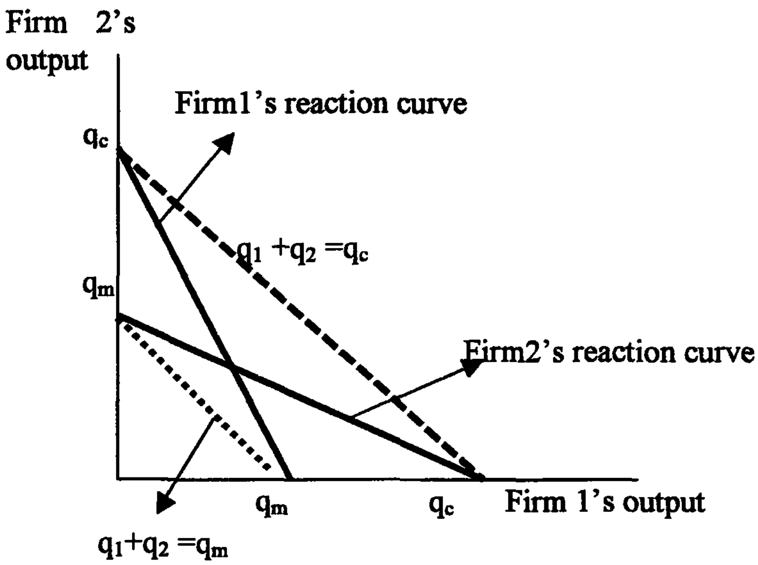

Figure 3-5 Equilibrium - Cournot duopoly

In Figure 3.6, the dashed line shows the case for a competitive market. If the Cournot equilibrium is compared with a competitive market, it can be concluded that, the combined output of both firms in Cournot equilibrium will be less than it would be in a competitive industry, therefore the price will exceed the competitive price. On the other hand, if output of this model is compared with monopolistic market, because the Cournot equilibrium point remains above the dotted line, which combines q_m of firm 1 with q_m of firm 2, output of the monopolistic market, Cournot model output will exceed the monopoly case. Therefore price falls short of monopolistic market.

Formulating these according to optimization of profit function for each duopolist for homogeneous goods case;

$$\Pi_i = P(q_1+q_2).\ q_i - c_i.q_i \tag{3.2}$$

$$\frac{\partial \Pi_i}{\partial q_i} = \frac{\partial P(q_1+q_2)}{\partial q_i}.q_i + P(q_1+q_2) - c_i = 0$$

$$P(q_1+q_2) - c_i = -\frac{\partial P(q_1+q_2)}{\partial q_i}.q_i\ . \tag{3.3}$$

where, $P(q_1+q_2)$ is the price determined in the market as a function of total supply, and c_i is the unit cost.

Consequently, Cournot duopolists exercise some market power, but because they act without any cooperation, they can't maximize the joint profit. As the number of firms in the market increases, the equilibrium output approaches to the competitive output, and the price moves towards the competitive price.

There are some implausible aspects in the above assumptions. One is on the identicality of firms. As it is the case mostly, and in container market example, cost structures of firms are normally not identical, at least the transportation cost violate identicality. Furthermore, in container market case, the commodities are in substitutive competition, therefore heterogeneous; so the simple model above needs to be enlarged to a market with more than two firms, which are not identical.

Referring to Daughety (1988, p:14-17), for homogeneous product, if marginal cost of firm 1 reduces to $c^* < c$, due to a new technology, which is not available to firm 2, the marginal cost curve of firm 1, shifts down and the profit maximizing output of firm 1 increases (Fig. 3.6). Therefore firm 1's reaction function shifts outwards.

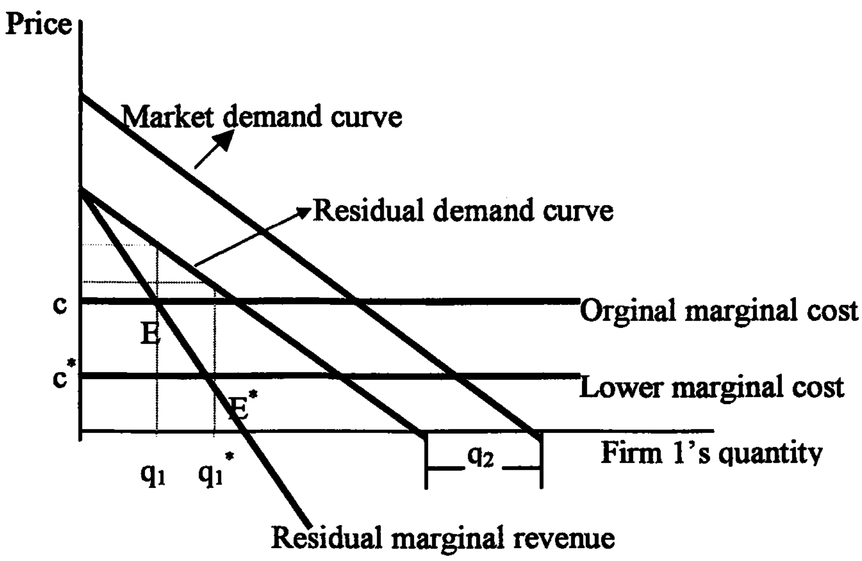

Figure 3-6 Firm 1's output decision after the cost reduction

3.2.1.1.2 Non-Homogeneous Product Case

Enlarging model furthermore to non-homogeneous goods case, in relation with container industry, two different goods with different prices make the formulation of the model as,

$$\frac{\partial \Pi_i}{\partial q_i} = \frac{\partial P_i}{\partial q_i(P_1,P_2)} . q_i(P_1,P_2) + P_i - c_i = 0$$

$$P_i - c_i = -\left(\frac{\partial q_i(P_1,P_2)}{\partial P_i}\right)^{-1} . q_i(P_1,P_2) \qquad (3.4)$$

This means that the quantity is a function of price of the good in question, as well as price of the substitutive competitor. As in container market of Turkey, price of the competitor goods serving to same purpose, especially PET price curbs growing rate of Turkish glass sector substantially.[9] Demand curve and price function can be expressed in duality as;

$$P_i = a_i - b_i q_i - c q_j \quad (3.5)$$

If the commodities are perfect substitutes, **c** is positive; if indepentent, c is zero, and if complements, negative.

$$Q_i = \alpha_i - \beta_i p_i + \gamma p_J \quad (3.6)$$

Here duality is between **a**$\Leftrightarrow\alpha$; **b**$\Leftrightarrow\beta$ and **c**$\Leftrightarrow -\gamma$, where α, β and γ can be expressed as a function of "**a**", "**b**" and "**c**". Especially between 1993 and 1998, PET resin prices were really very low, due to excess supply in that market, causing reduction in profit margins of both PET and glass suppliers.

Generally, in case of a market with few suppliers, each firm recognizes the interdependence. Assuming there is no coordination, each firm restricts its own output, thinking the others will do the same. On the other side, as it puts more output in to the market, revenue of its rivals will also go down. The more the market is concentrated, the greater the effect of output restrictions will be, and vice versa. This point highlights the most important implausibility of Cournot model in general. Fısher expressed this point as "The fault to be found in Cournot's reasoning is in his premise that each individual will act on the assumption that his rival's output is constant and will strive only so to regulate his own output as to secure the largest profit." (I. Fisher, 1898, p. 126)

One of the older economist, Adam Smith's view can be considered on the contrary of Cournot as well; " People of the same trade seldom meet together, even for

[9] Market share of glass for carbonated beverages reduced from 30,7% to 12,0% between 1995 and 1998 and forecasted to further decrease to 7,2% by 2001; for fruit juice decreased to 15,2% from 19%.

merriment and diversion, but the conversation ends in a conspiracy against the public or in some contrivance to raise prices." (Adam Smith, 1937,p:18) As firms recognize the mutual interdependence, the assumption of rival's holding their output constant is invalid. (Martin, 1994, p:126) This fact may be less strong for heterogeneous goods case, as the market divided between the two may be rigid due to consumer strategies towards any difference the goods have in their nature. This is the case for beverage container market. As PET is lighter in weight, it may better serve to large volume sales strategies. On the other hand low oxygen permeability may prevent PET to enter low volume sales market. Therefore price changes in any of the two are transmitted to the other market via a dashpot.

Besides this substitutive materials' competition in soft drinks sector, the global competition has a different perspective. In glass industry, as the capacity is pre-determined, leaving a margin for export, after domestic market is satisfied, firms try to sell this export margin in the world. In most of the developing countries, high quality bottles are imported, creating a market for the high technology and high capacity giant producers. If such a market is too far to be supplied from the current position, and if high quality container glass market is satisfactory there, these giants may prefer to make investment, where the market is. Otherwise, Bertrand model holds.

3.2.1.2 Bertrand Model

The choice between quantity setting and price setting is generally thought to be dependent on the technology, how elastic it is to alter the quantity. (Dixon, 1996, p:59-70). Despite this, the basic price setting oligopoly model, namely, Bertrand model, assumes a standard product all through out the market, namely, products are perfect substitutes. Therefore consumers prefer the supplier that charges the lowest price. In container glass market, product can be considered as identical globally, although there might be some minor changes due to quality, this will be neglected for the market in question, as the model will be on the giant producers goods, and as the quality of these producers is almost same.

As it is in the previous model, all firms take their competitors prices as constant, as they decide on their price. Referring to Figure 3.7, as firm 1 decides its price, it will see that, the other firm in the market, firm 2's price is P_2. Because the products are perfect substitutes, if it gives a price slightly higher than P_2, it will not be able to gain any share from the market, on the other hand, if it keeps its price, even a little short of P_2, it will take all the market. Firm 1's incentive is to determine price by making marginal revenue equal to marginal cost. But the best that can be done by Firm 1 will be to set price, slightly lower than P_2 as long as it is above the marginal cost. In this way, it will capture the entire market. Same thing is also valid for Firm 2. It will as well try to cut the price of firm 1. In this way, the equilibrium they will come will be the marginal cost. Neither firm will decrease its price any more, because, as the price remains below marginal cost, selling means simply loss. (Martin, 1994, p:133)

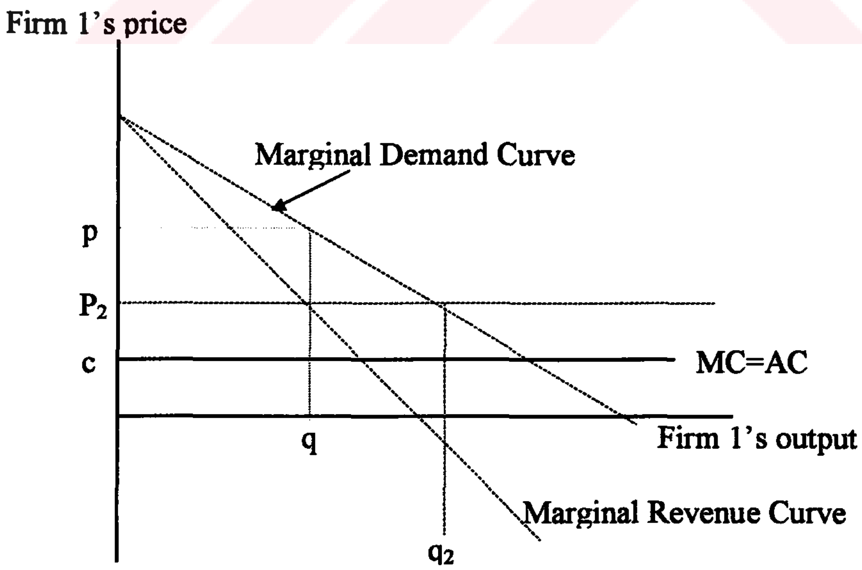

Figure 3-7 Firm 1's price decision, price-setting model, standardized product.

From the game theoretic point of view, firms come to Nash equilibrium[10], when firms prices are at marginal cost, in other words, they do not make profits; which concludes that, in this model even a duopoly would suffice to restore competition. This is called *Bertrand paradox.*

It is called a paradox, because it is hard to believe that a market with only two firm could not succeed in manipulating the market price to make positive profits. Besides this, it does not seem logical to enter a market with no positive profit from the entrant firms' point of view, thinking about the sunk costs. Hence, if it is not logical to enter a market, at the end, market turns out to be a monopolistic one. (See Tirole, J.; 1995 p:208-224)

Another implausibility of the model is due to the identical product assumption. (Martin, 1994, p:134) Products of different producers are always differentiated to some extent, at least by location.[11] Having a similar nature with this implausibility, if identical cost assumption is taken out of the model and if an asymmetric case assumption is made, the one with smaller marginal cost will charge a price that is slightly lower than the other's marginal cost. In this way, it will both make positive profit and capture the entire market. Because for the other firm, charging that price would mean loss. In this case, Bertrand competition is no longer welfare optimal.

Some generalizations are made to bring realism to Bertrand model. One of this is referred as Edgeworth solution. Edgeworth solved Bertrand paradox, by introducing the capacity constraints. Edgeworth (1897) (Tirole J.; 1995; p: 211- 212) exemplified a two firm market, with capacity restraint and with identical costs. At the first stage

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[10] Nash equilibrium is the equilibrium point that the players arrive, when they make their profit maximising selection, given the others selection.

[11] In such cases, price differential is more than offset by the difference in transportation cost. Hence the zero-profit price is no longer an equilibrium point.

the price equals to the marginal cost. However, as one of the firms increases its price, slightly above the marginal cost, the other faces with a demand that it cannot meet. In this way, the firm charging above the marginal cost, thus making positive profit will supply some of the clients. Such solution is no longer an equilibrium, and implies that, in models with capacity restraints, firms make positive profits and the market price is greater than the marginal cost.

One of the crucial assumptions of Bertrand competition is being a one shot game, where this does not reflect an economic reality. In particular, if one of the firms in a positive profit market decreases its price to capture the whole market, the other firm will follow, not to loose its share, and this will go till the no profit equilibrium point is reached. Therefore, this is not a single stage game, that permits the players to play only once and due to this reason firms will compare the short run gain to the longer run loss in price war.

Comparing Bertrand competition with Cournot, it seems that Bertrand may be a better approximation for industries with fairly flat marginal costs, and Cournot for those with sharply rising marginal costs. Besides, quantity competition can be seen as competition in choices of scale, where scale determines the cost function and thus the conditions of price competition. (Martin, 1994, p: 134)

Price modeling of glass industry would be meaningful, because, although whole capacity is not flexible to change, comparatively small export margin planned in this capacity can be assumed as flexible, by using the tool of stock compensation. The amount, which couldn't be sold within a year, can be kept in stock. More important than this, is the fact that, export market is more competitive than domestic market as market conditions and trends are harder to measure and correctly estimate.

As Bertrand and Cournot model can be used to explain the markets, where Sisecam and most of the other glass producers in the world are actually active in, for the new markets emerged as a result of new major technical developments, leader-follower model, namely Stackelberg model can be considered.

3.2.1.3 Stackelberg Model

The point of the Stackelberg model is that commitments matter because of their influences on the rivals' actions. Fudenberg and Tirole (1984) and Bulow, Geanakoplos and Klemperer (1985) have independently offered a framework to systemize these ideas. (Tirole, 1995, p.323)

Considering a two firm, two period model, where in period 1, firm 1 (incumbent) chooses some variable K_1, and firm 2 observes K_1 and decides whether to enter. If the second firm does not enter, the incumbent enjoys the monopoly position, and makes profit,

$$\Pi^{1m}(K_1, x_1^m(K_1))$$

Here $x_1^m(K_1)$ is the monopoly choice in the second period. On the other hand if firm 2 enters, their profits then will be

$$\Pi^1(K_1, x_1, x_2) \qquad \text{and}$$

$$\Pi^2(K_1, x_1, x_2)$$

If firm 1 chooses some level K_1 and firm 2 enters, the post entry choices x_1 and x_2 are determined by Nash equilibrium, for the satisfaction of stability.

Looking from the point of view of firm 1, the effect of the choices of firm 1 on the profit of firm 2,

$$\Pi^2(K_1, x_1^*(K_1), x_2^*(K_1))$$

can be determined by taking the total derivative with respect to K_1.

$$\frac{d\Pi^2}{dK_1} = \frac{\partial\Pi^2}{\partial K_1} + \frac{\partial\Pi^2}{\partial x_1}\frac{dx^*_1}{dK_1}$$

where the first term has a direct effect and the second has strategic effect.

Changing K_1, will make firm 1 having a direct effect on firm 2's profit. However, this term generally has zero effect, such as the case, where, K_1 is an investment that affects only firm 1's technology. Then the effect of firm 1, if any, is channeled through post entry period. The strategic effect on the other hand rises from the fact that, K_1 will change firm 1's post entry decisions. As a conclusion, it may be driven that, firm 1 will be tough, if $d\Pi^2/dK_1 < 0$; and soft vice versa.

This model generally holds for the major innovative applications in glass industry. This may be some product differentiation with a new technology, or a process innovation itself. The performance of the innovator, who is the incumbent as well, is observed in the market. The responses of the market, and the performance of the technology is tested in the mean time, by the way followers decide whether to enter the market. The incumbent enjoys monopoly position, till the followers enter the market.

The followers make research on alternative and more efficient solutions to reach the same result. In case of failure, they try to find the ways for license agreement. The details of technology licenses will be explained in the next chapter.

3.2.1.4 Collusive Behavior

Conditions in oligopolistic industries tend to promote collusion, since it is easy for the small number of firms to realize their interdependence. Collusion means increase in profits, decrease in uncertainty and a better blockation for entry. Although, collusive behavior is not easy to maintain, as it is possible for any firm to cheat, in addition to its being illegal. When it is made formally and openly, it is called *cartel*.

In case of collusive behavior, oligopolists determine the price according to shared market, as in the monopoly case, which is discussed below. However, in case of a decrease in cost of any firm in collusion, may cause a price war; although it is the firm's strategic choice to lower the price or not.

In world glass market, there are Technical Assistance Agreements or Technical Consortiums between some glass producers. These generally serve to solve technical problems they have, benchmarking activities or to share technical information. Any way as it was declared before, if there are a few number of suppliers in the market, their meeting may result in some form of collusive behavior that restricts competition. Although there is no case in this manner in container glass sector, it can be deduced that, this fact generally holds in glass market as well and parties of such technical assistance agreements may be hesitant to attack on the markets, where the other is active in.

Besides this, as the main strategy is full satisfaction of domestic countries for all giant glass producers, members of such consortiums may import glass from other members, and sell to domestic clients, in case they can't meet their demand. In this way they hinder domestic client's direct contact with foreign suppliers.

For beverage industry in domestic market, as the substitutive goods are becoming stronger and stronger, and as their technology is quite different than glass production, collusive behavior cannot be deemed to exist. For the other consumer industries, rules of monopolistic and contestable markets hold.

3.2.2 Dominant Firm Approach

There are two major points that distinguish a monopoly from a competitive market: one supplier and blockaded entry, where the first is to ensure that the supplier firm faces no competition actually, and the second, no potential competition.

In the simple monopoly models, the major difference between the competitive firms and the monopolist is that, the former is a price taker, because it is too small to affect the market price and the other is the price maker. As the competitive firm arranges the output, where the marginal cost equals price, the monopolist is powerful to affect the price and determines it, where its marginal cost equals to marginal revenue. If it makes any increase in the output, the market comes to a lower point in the demand curve, and makes the monopolist suffer a price reduction. (Fig. 3.8)

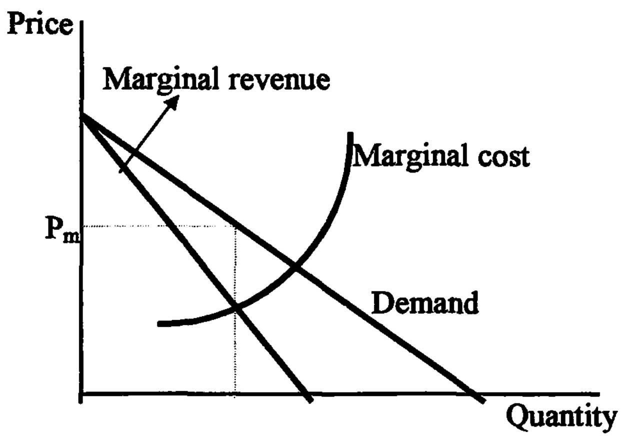

Figure 3-8 Demand, marginal revenue, and monopoly output.

Considering glass market in Turkey, Sisecam has neither an actual nor a potential competitor in wine, champagne, other alcoholic drinks, serum and almost beer container market. Therefore has market power as the dominant firm. However, competition of export glass put limitation on glass prices. In order to remove this danger, Sisecam's main strategy is to grow towards the neighbor countries and put a shield around Turkey for export glass.

Adam Smith (1937, p:61) wrote that, " The price of monopoly is upon every occasion is the highest, which can be got." But how bad it is can be determined by looking at the price elasticity of demand, which tells how sensitive the quantity demanded to price.

Monopoly is undesirable, because a monopolist will restrict output and charge more, and result in misallocation of resources. To measure, the inefficiency, it will be convenient to look at the welfare consequences of monopoly. With the assumption of constant returns to scale, marginal cost and average cost becomes the same (Same explanation is also valid for the case of, inconstant returns to scale.) As shown in Figure 3.9, if the industry is competitive, price will equal to marginal cost; with the quantity being demanded and supplied, Q_c. A monopolist will equate the marginal revenue and the marginal cost to maximize profit; and come up with a restricted output, $Q_m<Q_c$. The price difference will be $\Delta P=P_m-P_c$.

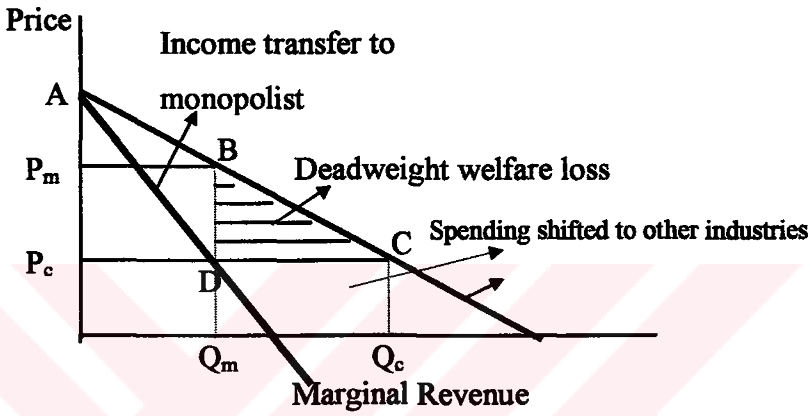

Figure 3-9 Allocative and redistributive effects of market power.

The cost to society of a unit product being c, the consumers, who will to buy the restricted amount $\Delta Q=Q_c-Q_m$ will be unwilling to pay the monopoly price and spend the $c\Delta Q$ to other products. By restricting output the monopolist artificially inflates the price of the monopoly goods and sends a false signal to the consumer and damages the allocation of resources.

The consumer surplus, being P_cAC, reduces to P_mAB, in monopoly case, where the P_mP_cDB transfers to the suppliers as surplus, and the other part DBE represents the welfare loss, namely "deadweight loss", resulting from the market power. This cost ignores the cost of the strategic efforts to obtain the market power. As it will be explained below, a firm may pursue a variety of strategies to gain and protect a position of dominancy. One of them may be static limit price application, but main protector of Turkish glass industry is "sunk costs".

A firm's investment in capital is said to be sunk, if its assets would have to be sold at a substantial loss, if it decides to leave the market. Entry, always have some sunk costs. The extent, to which it is sunk, determines the cost of capital. These costs place the entrant at a disadvantageous position by means of fixed and marginal cost compared to the incumbent.

The incumbent firm on the other hand can exploit this disadvantage to maintain its position. As the output of the incumbent firm increases, the residual demand of the entrant firm decreases, and it can come to a point that, the price, which is determined in the above explained fashion cannot cover the average costs. (Fig. 3.10)

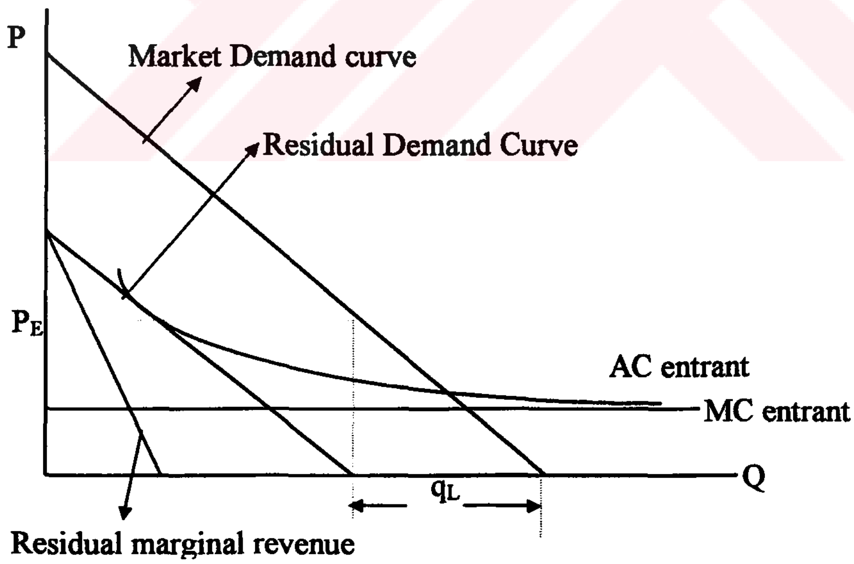

Figure 3- 10 Limit output and limit price

In Figure 3.10, the incumbent firm puts q_L units on the market, and the best price for the entrant, P_E, will be just equal to the average cost. Only a slight increase in the output of the incumbent can cause the entrant to loose. Therefore the limit output to deter entry is determined by two factors: the size of the market and the average cost curve of the potential entrant. The greater the extent to which, the costs are sunk, the higher the average costs of the potential entrant is; and the larger the size of the market, the more the quantity that must be put on the market to deter entry is. First investment in glass industry is very high. Sisecam, within the business cycles the market has, even in the period just before next investment, namely at the point where, demand meets and about to exceed supply, leaves a small margin of excess capacity to satisfy the market and prevent entrance of a potential competitor. In this period, implementation of investment plans normally has begun with the know-how it has, being at a one step forward.

Similarly at this stage, the dominant firm may decide on letting the potential entrant to enter in to the market and, to be the incumbent firm; or take the strategy to keep it a way from the market by comparing the payoffs of the two. If the market is very small and the sunk costs are very high, then the potential entrant will not find entry profitable, even if the dominant firm charges monopoly price. This case is called "*Blockaded Entry*". The simple monopoly model applies and such a market is called a " *Natural Monopoly*", as in the case of Sisecam as a glass producer. However, in global markets simple natural monopoly rules do not hold and, even natural monopolists are to plan sufficient capacities first to prevent import and entry of a financially strong competitor, then to make economic profits. With this reasoning, the above explained capacity and investment plans causes Sisecam's container glass division time to time enjoy dominancy in some market segmentations and time to time not.

On the other hand, if the costs are not sunk, the entrant has exactly the same cost structure as the incumbent, and the profit is economic to the same extent as the incumbent. The dominant firm can only keep the entrant out of the market, by charging a price that creates a zero economic profit. This kind of market is called "*Contestable Market*", having the same performance with the competitive markets.

As the main criteria to differentiate a natural monopoly is sunk costs, and in glass industry main protector of dominant firm is the sunkness of costs, it worth to analyze sunk cost in detail. The term "sunk cost" refers to the loss as a unit of capital is sold to some value α, where α is less then the value at which it was purchased, β. The case of α being zero is called absolute sunkness.

Baumol emphasizes the importance of sunk costs as

"Clearly when entry requires the sinking of substantial costs, it will not be reversible because, by definition, the sunk costs are not recoverable. However, if efficient operation requires no sunk outlays, then entry can, by and large, be presumed to be reversible, and the market can be presumed to be contestable." (1982, p:7)

For any business, the physical materials that are necessary may be sold at substantial loss as the firm decides to exit the market. Physical assets' being specific to that industry, increases the sunkness of costs.

Intangible assets are involved in any market. The entrant will at least collect some information about the market in question, before it takes the decision to enter. Such information is valuable as long as the firm remains in the market, so they are absolutely sunk. Organizational activities are another example to such intangible sunk costs. In addition to this, activities for product differentiation when it is necessary and technical know how can be considered among the sunk costs, although to some extent they may be recovered.

Glass production technology is deeply know-how based and control of process needs high technology research laboratories, suggesting another dissuasive point as a combination of both tangible and intangible sunk costs, for a potential competitor and appearing as an advantage of Sisecam for protecting Turkish market.

However, although for most of glass container articles, transportation costs are very high, for small articles especially supplied to pharmaceutical industry, transportation looses its barrier property for imports. To use this advantage in small volume pharmaceutical glass containers, Saint Gobain, French glass producer, who has the largest capacity in the world in container glass market, established a stocking unit in Turkey to supply to Turkish pharmaceutical industry. This investment has almost no sunk cost and lets Saint Gobain enter the Turkish pharmaceutical market, as it will maintain, continuous supply to clients, which is of great importance. Pharmaceutical industry's quality sensitive nature is important in this example, causing the client to be ready to pay more for high quality bottle. This condition encourages Saint Gobain to enter this market, through low cost investment, although its price will be slightly above Sisecam's due to transportation; this plus will significantly be less for small pharmaceutical items than the containers serving to other industries. Such a threat normally causes Sisecam to raise quality and satisfy client in this respect and keep the share of Saint Gobain as small as possible, even to cause exit. Although this is not an example of contestability due to pricing policy, glass container market for pharmaceutical industry is in a quality driven way prone to be contestable.

As mentioned before, glass market can be classified as naturally a market of dominant suppliers, due to optimum size of firms. Even this nature may not be enough alone to keep firms enjoy its dominancy forever. Therefore these firms must employ strategies to maintain their dominancy.

Sisecam's R&D activities, being the main subject of the thesis, R&D theory will be explained in detail in the next chapter.

4 RESEARCH AND DEVELOPMENT

Research and Development can be classified in to two types: process innovation and product innovation. Both are divided in to three phases: invention, innovation and imitation. Invention is the creation of new idea. Innovation converts this idea to practical use. The following step is imitation, others' copying of innovations. (Shephard, 1990, p:142)

Shy defined innovation as "Innovation is the search for, discovery, development, improvement, adoption and commercialization of new processes, new products and new organizational structures and procedures." (Shy, 1995, p:221) It can range from scientific concepts to practical ideas.

Process innovation can be summarized as cost reducing efforts by altering the ways given products are made. Product innovation on the other hand, creates a new good, without any change in the process. It is sometimes regarded as a cost reducing innovation that reduces the cost of a product from infinity to a finite level.

In this chapter, the theory and evidence on the relationships among market power, firm size, and technological progressiveness will be examined. The structural characteristics that seem likely to affect the rate of technological advance in an industry will be reviewed; and the policy questions raised by the patent system and by research joint ventures will be discussed.

4.1 OPTIMAL TECHNOLOGICAL CHANGE

Technological change occurs when the resources for invention and innovation are applied to generating new ideas and products. These resources are used, up to the levels at which their benefits equal their costs. The cost-benefit relation and the efficient choice are illustrated in Fig. 4.1. The array of decreasing pay-offs shown in the figure is the marginal returns for R&D expenditure. Returns are only predictions and the pay-offs are expressed as rate of returns.

The optimum level of R&D activity is shown at value R, representing the value, where the marginal rate of return curve intersects the marginal cost curve. The projects on the right of R has greater cost than return, therefore R&D projects can be done up to R. In order to yield efficient amount of progress, R&D level has to be optimized at value R in Fig. 4.1, instead of maximized. (Shephard, 1990, p:146-147)

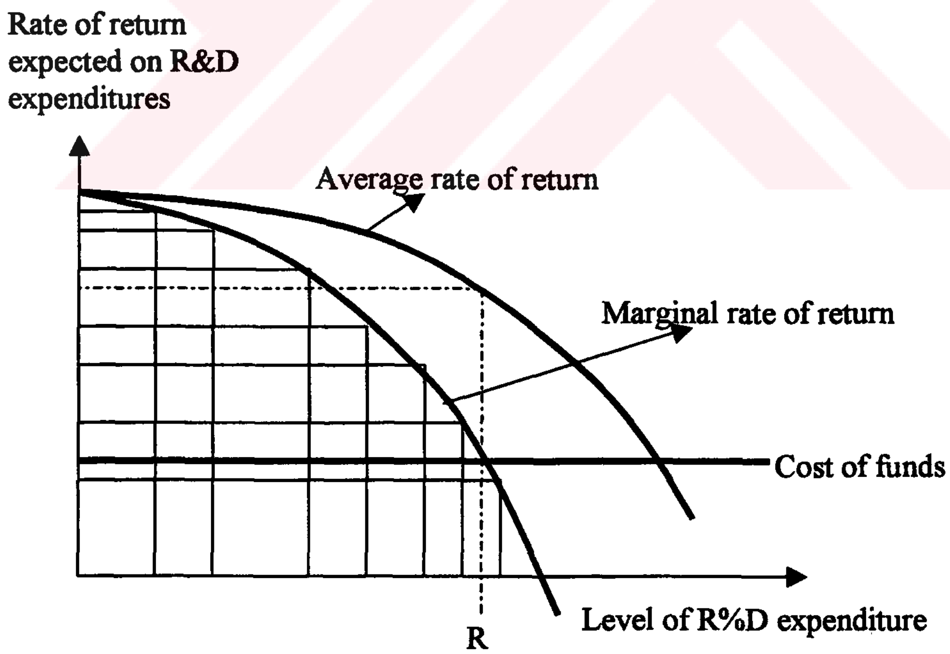

Figure 4-1 Illustration of rational choices by an innovating firm. **(Shephard, 1990, p.:147)**

If we consider an industry with a homogeneous product, and suppose that the firms in that industry compete in prices, possessing identical technologies, then, the same unit production cost can be assumed for all of the firms in that industry. The equilibrium is illustrated in Fig. 4.2 by point A.

If one of the firms in this industry spends on R&D for cost reducing innovation and comes up with a unit cost of $c<c_0$. If the price that would be charged by a monopolist is assumed as $p^m(c)$, which is determined by equating MR(Q)=c; innovation can be regarded as drastic or major, if $p^m(c)<c_0$; and said to be non-drastic or minor, if $p^m(c)>c_0$. In Fig 4.2, both types of cost reducing innovation are illustrated. A cost reduction from c_0 to c_1 is what we call a small innovation. That is the cost reduction is not large enough, to give the monopoly power to the innovating firm. The only advantage of such an innovation will be to make the innovator to gain positive profit, equal to $(c_0-c_1)Q_0$. On the other hand, a cost reduction from c_0 to c_2 illustrates a large cost reducing innovation, since the innovator firm can simply charge pure monopoly price and undercut its rivals, with the new cost structure, $p_2^m(c_2)<c_0$ with reduced market price and increased quantity, Q_2.

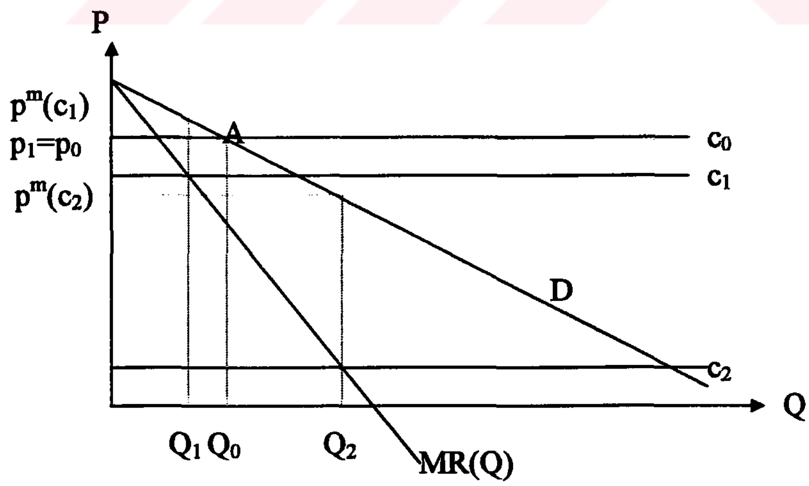

Figure 4-2 Process Innovation

4.2 FIRM SIZE AND R&D

An analysis of Demsetz (1969) confirms that incentive to innovate is greater in a competitive market than a monopoly but encouragement is better for monopolist. "That there are special adverse effects of monopoly on the incentive to invention, a framer of public policy would deduce that antitrust should be pursued more diligently than is dictated by considerations of output restriction only. But he would be wrong, if it is thought desirable, to encourage invention by granting monopoly power through the patent or through secrecy. The above analysis suggests that antitrust should be pursued less diligently than is dictated by considerations of output restrictions only for at least in the linear model of two industries of equal output size, the more monopolistic will give the greatest encouragement to invention." (Demsetz, 1969, p:18-19)

Schumpeter, one of the great economists on the other hand, argued that, large firms and monopoly power might very well promote technological progress, and that market populated by large firms might best serve society over the long run. " As soon as we go into details and inquire into the individual items in which progress was conspicuous, the trail leads not to the doors of those firms that work under conditioned of completely free competition but precisely to the doors of the large concerns." (Schumpeter, 1975, p.83)

Schumpeter's hypothesis linked size of firm and innovation for three distinct reasons. First only a large firm could bear the cost of R&D, second, a large and diversified firm could absorb failures by innovating on a wide front. Third, it needs some element of market control to reap the rewards of innovation, although there is no evidence that large firms spend proportionately higher than small firms on R&D. There are theoretical reasons for expecting concentration to be a determinant of R&D expenditure, though these relate more to the rivalry of oligopolistic competition than the incentive of assured markets in monopolized sectors. R&D efforts of a particular firm will depend also on competitive stance adopted by the firm.

Types of firms that are quick to adopt new technology, Mansfield suggested that size of firm was the main determinant, given the profitability of the innovation. Larger firms are more able to meet the conditions for a particular innovation, and so their speed of response is likely to be faster. (Hay&Morris,1979, p:441-471)

Figure 4.3 shows the effect of a cost reducing innovation on the output decision of a profit-maximizing monopolist. The average cost per unit is assumed to be constant before and after the innovation, and the demand curve is assumed to be linear.

A profit-maximizing monopolist will select an output that makes its marginal revenue equal to its marginal cost. The monopoly profit when average cost is c_1 is therefore $(P_1-c_1)Q_1$. The gross increase in monopoly profit due to innovation is

$$(P_2-c_2)Q_2 - (P_1-c_1)Q_1 \qquad (4\text{-}1)$$

where this measures the incentive to innovate under product market monopoly. If the above equation is played with algebraically, the equation turns out to be the marginal revenue from the sale of $\Delta Q = Q_2 - Q_1 > 0$ units minus the post innovation producing cost of the same amount minus the cost saving ($\Delta c = c_2 - c_1 < 0$) on the Q_1 units of output, that had been produced before the innovation. Namely, for a monopolist, the profit increase due to innovation is the marginal revenue less marginal cost and the cost savings.

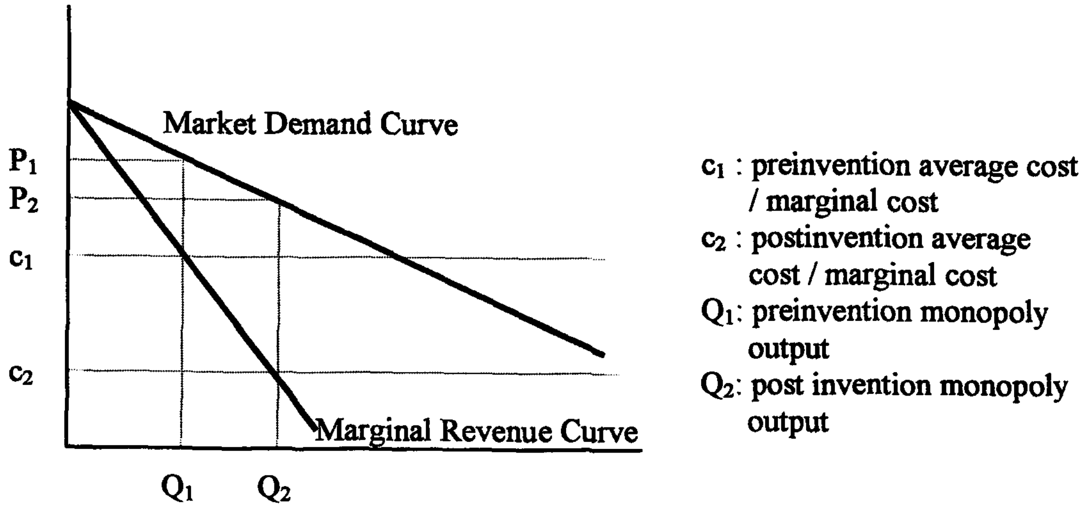

Figure 4-3 The incentive to innovate under monopoly

4.3 INNOVATION RACE

Timing of innovation plays a highly important role in the market. The firm, that is first to discover a new technology, or a new product gains advantage, because it is eligible to obtain a patent protection, which results in earning monopoly profits for several years. Because consumers associate the innovator with a higher quality producer, will therefore be willing to pay a higher amount for the brand associated with the innovator. (Shy, 1995, p: 224)

It is assumed that a two firm industry is searching for a new technology or for a new product. Each firm k can engage in R&D by investing an amount of I, where the probability of discovering a new technology or a new product is α and the pay-off is V, in case the firm is the sole discoverer; V/2, if both firms discover, and 0 otherwise. The expected profit of firm k from investing in innovation is denoted by

$E_{\pi k}(n)$ where the number of firms engaging in similar investment is n (which is 2 in this case). The investment expenditure is denoted by i_k.

If only one firm makes such an investment, then its expected profit is given by $E_{\pi 1}(1)=\alpha V-I$. The investment decision in such a case will be given by;

$$i_1 = \begin{cases} I & \text{if } \alpha V \geq I \\ 0 & \text{otherwise} \end{cases} \qquad (4\text{-}2)$$

If both of the firms in the industry undertake R&D, besides the uncertainty of whether the firm will be successful in innovating a new product or a new technology, there is the market uncertainty, that is whether, the rival will be successful or not in innovation.

The expected profit in this case, will be;

$$E_{\pi k}(2) = \alpha(1-\alpha)V + \alpha^2 V/2 - I \qquad (4\text{-}3)$$

The following will be the sufficient condition for the firms to engage in R&D

$$i_1=i_2=I, \text{ if } \quad \frac{\alpha(2-\alpha)V}{2} \geq I \qquad (4\text{-}4)$$

Each of these conditions is illustrated in Fig. 4.4. (Shy, 1995, p:226)

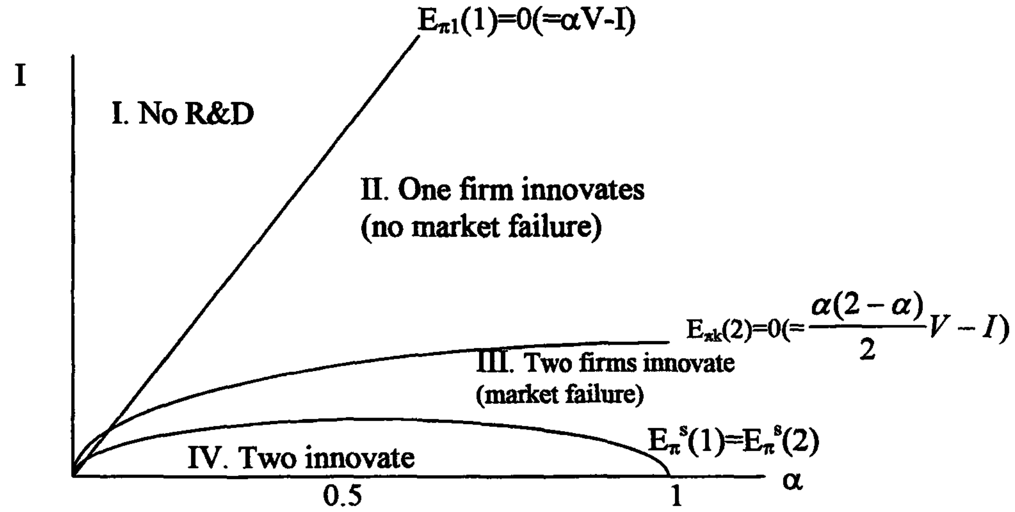

Figure 4-4 R&D race between two firms.

From the point of view of social welfare, increasing the number of firms engaging in R&D investment, will increase the probability of discovery, on the other hand, the expenditure on R&D associated with duplication of efforts as well.

To determine the optimal number of firms engaging in R&D for welfare maximization, the two following expected profit functions are compared, Equation (4.5) the one firm engagement in R&D, with Equation (4.6) showing, two firm engagement in R&D;

$$E_\pi{}^s(1) = \alpha V - I = E_{\pi 1}(1) \qquad (4\text{-}5)$$

$$E_\pi{}^s(2) = 2\alpha(1-\alpha)V + \alpha^2 V - 2I \qquad (4\text{-}6)$$

$E_\pi{}^s(2) \geq E_\pi{}^s(1)$ if and only if $\alpha(1-\alpha)\mathrm{V} \geq \mathrm{I}$. This means that, the region above the $E_\pi^s(1)= E_\pi^s(2)$ curve in Fig.4.2 is where the socially optimal number of firms that engage in R&D is one. "For region 3 in Fig. 4.2, the market failure condition, in which it is socially desirable to have at most one firm engaging in R&D but in equilibrium two firms engage in R&D, occurs only in region III, where the innovation cost I, takes the intermediate value. Formally, $E_{\pi}^{s}(2)<0$ but $E_{\pi k}(2)>0$, when $\alpha(1-\alpha)V<I<\alpha V$." (Shy, 1995, p:227)

4.4 COOPERATION IN R&D

Firms' engagement in activities that reduce competition is prohibited by antitrust legislation, where any form of collusion aiming or resulting with the increase in prices or decrease in competition, is also included in the scope of antitrust. But for the collusion or joint ventures established for R&D, the legislation is not clear enough. For the cooperative R&D, it is generally asked, whether joining together reduces competition, namely whether they are anti-competitive, and even if they are anti-competitive, whether they result in efficiency gain or vice versa. Unless the R&D joint ventures offer gains in efficiency, it is not permitted. Therefore, such joint ventures are evaluated with rule of reason, instead of per se rule.

The US legal system is less supportive for R&D joint ventures than EC. According to the Clayton Act, allegations that firms use price fixing permit suing for treble damages. Therefore, there is a question of whether cooperation in R&D can open a channel of communication among firms to explicitly or implicitly collude on prices. Despite these suspicions, Congress has recognized that the potential benefits associated with cooperative R&D and in 1984 enacted the National Cooperative Research Act (NCRA), which states joint R&D ventures must not be held illegal per se. NCRA established a registration procedure for joint R&D ventures. The firms that register are immune from paying treble damages on any antitrust violation, but the maximum penalty for these firms is limited to damages, interest and costs. (Shy, 1995, p:247)

Sometimes, it is hard to distinguish between the joint R&D and joint commercialization, since the decision for the latter can be viewed as the last step of R&D process. Even the R&D joint venture concluded with joint commercialization, may result with high prices, it may be regarded as useful to society, since there might be no product at all, if such a joint venture is not established.

Considering a two stage game with two firms, in which t=1, firms determine how much to invest in cost reducing R&D and at t=2, they engage in Cournot quantity game in a market for a homogeneous product, to explain the way that the parties determine their level of efforts for research. By Shy (1995), the demand function is assumed to be p=100-Q. The amount of R&D taken by firm j is taken to be x_j, where j=1,2 and the unit production cost by $c_j(x_1,x_2)$, where it is assumed to be a function of only R&D investment.

$$C_j(x_1,x_2)=50 - x_j - \beta x_k \quad j \neq k\,, \ j=1,2 \quad \beta \geq 0$$

β refers to the spillover effect in the market, namely, the effect of the R&D of the other firm on the cost reduction level of the firm itself, and it is assumed to be positive. The cost of R&D is denoted by $TC_j(x_j)$ for firm j. It is further assumed that, the cost per unit R&D increases with the size of the lab, namely, they operate with decreasing returns to scale.

$$TC_j(x_j) = \frac{(x_j)^2}{2} \qquad (4\text{-}7)$$

As stated above, in the first stage firms decide on the level of R&D, and in the second, they compete by the level of output. This stage follows the first, so the cost levels can be taken as given, because they are determined by the level of R&D at the first stage.

$$\pi_j(c_1, c_2)\Big|_{t=2} = \frac{(100 - 2c_j + c_k)^2}{9} \quad \text{for } j = 1,2 \;\; j \neq k \qquad \textbf{(4-8)}$$

In the first stage, each firm chooses its level of R&D non-cooperatively, with rival firm's level given. If the Nash equilibrium is looked for, by substituting (4.7) in to (4.8) and solving for the first derivative equal to zero with the symmetry assumption between the firms, the non-cooperative level of investment appears to be;

$$x^{nc} = \frac{50(2-\beta)}{4.5 - (2-\beta)(1+\beta)} \qquad \textbf{(4-9)}$$

On the other hand, if the level of R&D for both firms are chosen cooperatively, to maximize their joint profits and in the second period they compete in quantities; the maximum of $(\pi_1 + \pi_2)$ is to be taken as the first order condition.

$$\frac{\partial(\pi_1 + \pi_2)}{\partial x_j} = \frac{\partial \pi_j}{\partial x_j} + \frac{\partial \pi_k}{\partial x_j} = 0 \qquad \textbf{(4-10)}$$

$$x_1^c = x_2^c = x^c = \frac{50(\beta + 1)}{4.5 - (\beta + 1)^2} \qquad \textbf{(4-21)}$$

can be found to be the cooperative R&D level.

Comparing the results reached at, for both cases, cooperation is found to be making the profits of the firms increasing; and the spillover effect is found to be having the major role, in determining either to cooperate or not; if the spillover effect is high, then tendency for cooperation seems to be higher and vice versa. (Shy, 1995 p:229-232)

Simpson and Vonortas (1994, p:79-92), offered a similar model and concluded that, in the absence of spillovers, meaning equivalence between R&D and any production investment in non-cooperative innovation can be excessive. However, even a small spillover may be enough to reduce private R&D to suboptimal level. A research joint venture on the other hand, may lead to greater output, hence welfare.

4.5 PATENTS

A patent is a legal document granted by the government to the inventor, giving the inventor the sole right to exploit the particular invention for a given number of years. (Shy,1995, p:233) In the United States, the patent is granted for seventeen years and cannot be renewed, in EC for around 20 years. (Shy,1995, p:245). In fact the development of patent law was needed to secure the monopoly rights for special reasons such as to reward the innovator. Despite the market distortion it creates, it is essential for growing economies, since it encourages new product development and process innovation.

A patent can be granted for products, processes, plants and design. In order to grant a patent to an invention, it has to satisfy following requirements: novelty, namely, the invention should not be patented inside or outside of the country; non-obviousness, refers to the requirement of demonstrating some advance; and usefulness, to prevent the inventions that contain novelty and non-obviousness but not serve to any purpose, to be patented. A patent cannot be granted, if it infringes on the older patents. (Shy, 1995 p:246)

The US patent system differs from the others to some extent. In this system, the principle of first to invent applies, and the first inventor takes the priority assignment, from the ones applying for the same patent. But the second innovator keeps the first one to exercise continuous diligence. In EC system, first to file principle applies, which is easier to enforce. (Shy,1995, p:246)

It is not easy to measure the social value of a patent. The goals it has can be divided in to two basic categories: to provide firms with the incentives for producing know-how and to make the new information concerning the new discoveries available to the public as fast as possible, where this reduces duplication of R&D. Fast dissemination of information may cause some infringements on the older patents, in order to prevent this, the innovators need extra protection, because know-how is easy to duplicate and steal if it is compared with other goods. Once it is publicized, the other firms will imitate it with the enforcement of intense competition, thereby reducing the price to unit cost. With such conditions, no firm would ever engage in R&D, which would result in stagnancy of the economy. That's why the duration of the patent protection is of high importance. To investigate the optimal duration of a patent for a society, Nordhaus (1969) and Scherer (1972) provided a simple method of calculation.

It is assumed that an investment of x in R&D reduces the firm's unit costs from $c>0$ to $c-x$. Assuming a minor innovation; namely $p=c$, and no change in output, Figure 4.5, where the demand is given by $p=a-Q$, $(a>c)$ illustrates the market before and after the innovation.

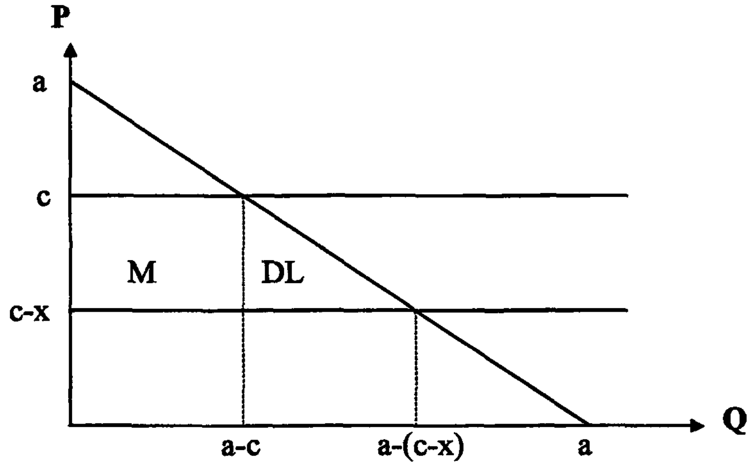

Figure 4-5 Gains and losses due to patent protection.

Since the price charged does not change, the area shown by M appears to be the innovator's gain in profit. If the granted duration for the patent is $T \geq 0$ periods, the profit enjoyed by the innovator becomes M for T periods, and zero from T+1 and on. The area DL is the deadweight loss of the society resulting from the monopoly power given to the innovator by the patent protection. For the first T period following the innovation, the society's gain occurs to be only M, the profit of the innovator, and afterwards, the gain of the society becomes M+DL. To develop a dynamic model, the discount factor ρ is inserted in to the model, where 0<ρ<1. In what follows, a two stage game, in which the duration, T is set by the government at the first stage, and at the second stage, the firms determine their level of R&D, with the patent duration given.

$$\max \pi(x;T) = \sum_{t=1}^{T} \rho^{t-1} M(x) - TC(x) \qquad (4\text{-}32)$$

It can easily be seen from the graph that M(x)=(a-c)x and $DL(x) = \frac{x^2}{2}$. Inserting these in to (4.12) and solving the first derivative equal to zero, the following can be found;

$$x^I = \frac{(1-\rho^T)}{1-\rho}(a-c) \qquad (4\text{-}13)$$

which is the innovator's optimal level of R&D. This implies that, R&D level increases with the duration given by the government; with an increase in demand, increase in the discount factor (or a decrease in the interest rate) and decreases with an increase in the unit cost.

For the government, welfare maximization can be modeled;

$$\max W(T) = \sum_{t=1}^{\infty} \rho^{t-1} M(x^I) + \sum_{t=T+1}^{\infty} \rho^{t-1} DL(x^I) - \frac{(x^I)^2}{2} \qquad (4\text{-}14)$$

turns out to be;

$$\max W(T) = \frac{(a-c)x^I}{1-\rho} - \frac{(x^I)^2}{2}\frac{1-\rho^T}{1-\rho} \qquad (4\text{-}15)$$

which, is finite.

4.6 LICENSING AN INNOVATION

Technology transfer gains special importance, even over R&D for the less developed countries. The priority of technology in economic growth is enhanced further, as nowadays, advances in technology determines the international competitiveness. (Alavi, 1999, p:21-38) Because it is a crucial input in the industrialisation of development of countries, to follow up the developments in this manner, one of the most appropriate indications of the dependency on foreign technology in developing countries is the increasing trend of foreign technology license payments[1].

Majority of the technology required for industrial development is patented and the patents are owned by large corporations in developed countries. It is referred by Alavi (1999) that, the bulk of technological activity in the world is accounted by the top ten countries stated in Table 4.1, which simply corresponds to 95% of the total by patents registration. In developing countries, technological capability is built mainly by acquiring foreign technology through transfers.

[1] The other indication is stated to be the foreign direct investments by Alavi, (1999).

Table 4-1

Major Source Countries of Technologies

Country	R&D Expenditure 1993		US patents taken 1977 - 96		Technology fees received 1993	
	Billion $	% Of total	Billion $	% Of total	Billion $	% Of total
USA	166,3	39	985,3	570	20,4	40
Japan	74,4	17	307,6	18	3,6	7
Germany	37,1	9	136,2	8	7,3	14
France	26,4	6	52,7	3	2	4
UK	21,6	5	52,8	3	2,9	6
Italy	13,2	3	22,1	1	0,9	2
Canada	8,4	2	34,4	2	0,9	2
Netherlands	5,1	1	16,9	1	6,2	12
Sweden	4,8	1	17,3	1	0,4	1
Switzerland	4,2	1	25,5	1	2	4
Subtotal	361,5	84	1650,8	95	46,6	91
World	428,58	100	1732	100	51	100

Source: **Kumar, 1998, p:14**

Licensing the patented technologies to other firms is common on national scale as well, in either exclusive licensing or licensing to several firms form. There can be several types of licensing by means of fee payment, a fixed-fee licensing, which is a fee paid without considering the units sold and a per unit fee, that is a fee paid for every unit sold. Profitability of licensing technology to a rival firm, which did not, invested on R&D, is surveyed by Kamien (1992).

A two firm model is constructed with Cournot competition. It is assumed that firm 1 has invented a minor cost reducing process, indicated by a lower unit cost $c_1=c-x$, where the unit cost for the non-innovating firm is c_2=c. It is compared, the non-licensing case and licensing less costly technology to firm 2, for the benefit of firm 1. If the licensing agreement is made according to the per unit fee, then firm 2 will pay a certain amount, ε for each unit sold. Assuming ε is high enough to prevent firm 2 to increase its output, the profit of firm 1 will be; $\pi_1= \pi_1^c(c_1,c_2)+\varepsilon q_2^c(c_1,c_2)$. That is firm 1 gains some of the surplus generated by the cost reduction in the production of firm 2, in addition to its profit due to the innovation. This result implies that, in a Cournot environment, licensing a cost reducing innovation can increase the profit of firms and aggregate welfare also increases as result of licensing, due to the increase in inventor firm's profit, all other's remaining same.

On the capability side of the issue, two types of technology transfer is referred, unpacked and packaged. (Alavi, 1999, p:21-38) Unpacked transfer mainly involves transfer of title, the right in itself and basic engineering knowledge. It usually occurs between partners who are at the same technical level. Packaged transfer, on the other hand, involves not only grant of the right to use the technology, but also transfer of a good deal of other information related to the technology to the recipient. This type of transfer usually occurs between unequal partners, i.e., partners who are not at the same technical level.

In developing countries, the type of technology transfer received is packaged transfer, where recipients are granted the right to use the technology under a licensing agreement. There are different kinds of agreements:

1. License as the main subject of the agreement (contractual main obligation). This includes:

  a. a license for a patent, without collateral obligations (patent license agreement)
  b. an agreement concerning the transfer of know-how *per se* without any collateral service or delivery (know-how agreements).

c. an agreement concerning a patent license together with the transfer of know-how, or vice versa (agreement with a mixed subject)

2. License as a collateral subject (contractual collateral obligation). This consists of:
   a. an agreement for services within which a patent and know-how are also transferred.
   b. an agreement for the delivery of goods (agreement of sale for the delivery of equipment or a complete plant) in which a patent and/or know-how are/is also transferred.

3. Special agreements, e.g., an agreement for the foundation of an enterprise.

There are some papers discussing the benefits of such technology transfer, and evaluating technology transfer as a stimulator for domestic R&D for LDC's.[2] (Basant & Fikkert, Braga & Willmore, Deolalikar & Evenson, etc.) Government policies regarding technology transfer limitations for such countries are discussed to optimize the social welfare and to stimulate the R&D, when technology transfer and R&D are substitutes for one another.

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[2] Alavi (1999) mentioned about the foreign direct investments as another source of technology transfer besides licensing, to have positive effects for domestic R&D. Many multi national companies prefer to intensify overseas research activities. It is stated that, in a study of 55 US and middle Atlantic firms, it was found that, the proportion of overseas R&D to be positively related to the proportion of subsidiary sales, negatively to exports and positively to firm size. As well as the size of the existing market, the per capita income is referred to have a positive effect.

4.7 GOVERNMENTS AND INTERNATIONAL R&D RACES

Governments never leave R&D to be completely performed by the free market, but intervene either by the research made in the universities or by the direct subsidies to the firms in the market. Competition in international markets generates incentives for the governments to subsidize the domestic firms' R&D.

Brander and Spencer (1983) modeled the subsidizing process innovation in the following way. Two countries denoted by j=1,2, each of which has one firm producing a homogeneous product only for export to be sold in the world market are considered. World demand for the product is assumed to be p=a-Q; and the pre-invention unit cost is c, where 0<c<a. The amount of R&D sponsored by the government is denoted by x_j, which reduces the unit cost to c-x_j; and the cost of the R&D to the government is $TC_j(x_j)=(x_j)^2/2$.

$$Q=q_1+q_2 \tag{4-46}$$

$$\pi_1=(a-(q_1+q_2))*q_1-(c-x_1)*q_1 \tag{4-17}$$

$$\pi_2=(a-(q_1+q_2))*q_2-(c-x_2)*q_2 \tag{4-18}$$

Assuming Cournot competition;

$$\frac{\partial \pi_j}{\partial q_j}=0 \quad j=1,2 \tag{4-19}$$

Solving (4.19) for q_1 and q_2 and putting in to (4.17) and (4.18) results with;

$$\pi_j = \frac{(a-2(c-x_j)+c-x_k)^2}{9} \qquad (4\text{-}20)$$

The welfare of the society can be determined by the profit of the firm minus the R&D cost. The R&D level of the other country is taken as given for each country, and welfare is maximized according to the level of R&D of its own.

$$\max W_j = \pi_j - TC_j(x_j) = \frac{(a-2(c-x_j)+c-x_k)^2}{9} - \frac{(x_j)^2}{2} \qquad (4\text{-}51)$$

The reaction function of each government can be determined by equating the first order derivative of the above equation to zero;

$$x_j = R_j(x_k) = 4(a-c) - 4x_k \quad \text{j,k} = 1,2;\ \text{j} \neq \text{k} \qquad (4\text{-}22)$$

which shows that, the reaction functions of R&D of countries are strategic substitutes. That's to say, if one reduces its level, the other increases and if one selects zero level of R&D, the other sets a positive R&D. Besides this, the equilibrium level of R&D subsidization increases with a shift in the world demand, because the cost function will be multiplied by a higher magnitude, and decreases with initial unit cost.

Another aspect of government policy could be on technology transfer side, which could be a handier tool for less developed countries, to determine the level of both technology transfer from developed countries, and the level of substitutive R&D. As Basant and Fikkert (1996) argued, R&D and technology purchase are substitutes for one another in the production of knowledge. Therefore a sufficient condition for the restriction on technology purchase, would stimulate R&D as a tax on technology purchase may be welfare improving whenever the marginal social return to R&D exceeds the marginal private return. However, the elasticity of R&D to a tax on technology purchase gains importance here. If it is too small, response can be minor, which means high private cost for R&D stimulation, as well as a major welfare loss.

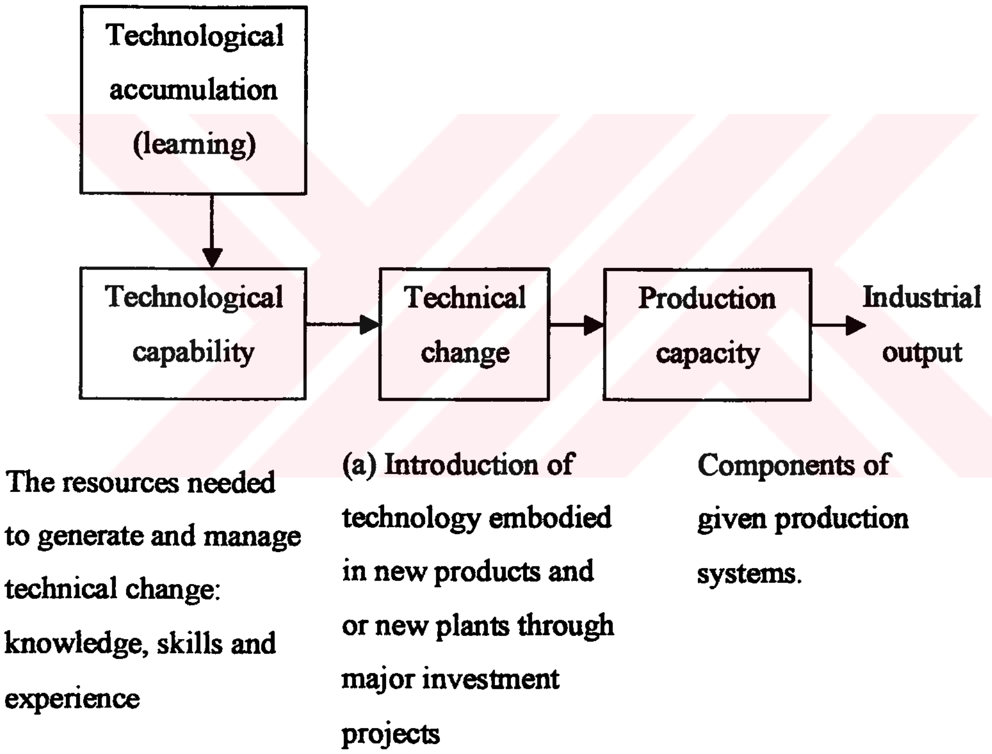
5 TECHNOLOGY TRANSFER vs. R&D FOR THE FIRMS IN DEVELOPING COUNTRIES

Having described the market determinants of glass sector and R&D theory, the model is based on comparative analysis of the effects of R&D and technology transfer on productivity and their substitutive relation over years.

There are numerous studies concentrated on productive and competitive effects of R&D for firms in developed countries and some to analyze the technology transfer issue from the licensor's point of view. On the other side, for the developing countries, technology import gains prior position compared to R&D over productive gains for licensee firms. R&D in developed countries is mainly on product or technology innovation; however, in developing countries, it turns out to have a tendency towards improving existing technology and creating necessary technological environment to transfer or sometimes imitate the invention in developed countries with less and known costs.

This import and adapt strategy as referred by Katrak (1985), were sometimes criticized on the grounds that it may inhibit the development of an indigenous technology capability and consequently make the country permanently dependent on imported technology. There are opposing views as well stated by Katrak (1985), claiming that the imported technologies is important in the first years only, and in the following years, as expertise is gained to adapt the imported technology to the existing situations of firm and country, an indigenous technological base will be built up to enable the firm to reduce the future dependence on imported technology, even to be self reliant in technology. Katrak defined technological self-reliance as an improvement in an enterprise's technological capability relative to those in enterprises in other countries. "An enterprise will be said to be becoming more self reliant in technology if, over a period of time, its expenditures on imported technologies decrease relative to its expenditures on R&D."

Bell and Pavitt (1997, p: 89) expressed accumulation of technological capability in the following schematic way:



Generally Indian researchers focused on analysis of the effects of technology transfer on productivity as well as its stimulator characteristic on domestic R&D. Basant and Fikkert (1996) made an analysis from this perspective over all Indian industries. They claimed that, as the firms in developing countries struggle to gain an increasing share from the global market, they follow technology developments more and more seriously and the accumulation of knowledge over years, stimulate domestic R&D. However, they concluded that, estimated rate of return to technology purchases are much higher than most estimates of the returns to R&D from either developing countries or India, especially for scientific firms. More specifically, results of their model was interpreted as, "R&D and technology purchase as substitutes; private returns to technology purchase expenditures are much higher than those to R&D in India". Their conclusion differs from Ferrantino (1992), who found no systematic impact on Indian firms' own R&D and technology purchase expenditures on productivity.

Ferrantino used firm level data from the years 1975 -1981 to examine the effects of technology expenditures on overall costs and relative factor use. He assumed that technology effort is cumulative over time and effect of technological effort is inversely proportional to the level of output, i.e. it takes a proportionately longer technological effort to alter the cost structure of a large firm. What Ferrantino basically concluded is, the cases in which non-purchasers of technology appear more efficient than purchasers of technology. Many of the non-purchasers may be efficient because of learning by doing effect. He further suggests that, the quality of managerial effort in the direction of increased efficiency is more important than any particular pattern of expenditures. On the other hand exorbitant tax incentives granted to firms, which report formal R&D activities are claimed to be a reason of lack of systematic relation between R&D and technology transfer. This tax incentive caused firms to classify many routine maintenance and repair activities as R&D (Ferrantino, 1992).

The reasons for concentrating on India on research and technology import analysis, are stated to be the long years, the country has followed the import and adapt technology strategy; and the government's declared objective on technological self-reliance. It is generally mentioned that Indian R&D were intended mainly to adapt imported technologies for commercial use. There are other papers concentrated on developing countries' such technology transfer activities. Braga and Willmore (1991) mentioned about Brazil and Canada as "Firms in developing countries like Brazil, or even smaller industrial countries like Canada find it difficult to appropriate the rents from new technology, hence devote few resources to basic innovative research. Instead they typically direct their R&D activity toward the assimilation of foreign technology and its adaptation to local conditions."

Braga and Willmore (1991) besides Ferrantino, Bassant and Katrak, claimed that the relationship between R&D and technology transfer might be one of complementarity, although they are stated to be substitutive. It was gone so far that "technology imports have been the most significant stimulant to the development of Japan's own R&D industry" (Ozawa, 1985, p:241). Braga and Willmore made the first study on Brazilian determinants on technological activity in the formation of industrial policy. What they concluded in this industry-based study is that, complimentarity dominates substitution between technological imports and domestic effort. He mentioned about the activities to assimilate the imported technology too, as Brazilian industrialists' greater access to imported technological knowledge is a certain way to increase their own technological effort. With this conclusion, Braga and Willmore's saying is not on the contrary of what the others said. Most of the studies in this context as the above referred ones concluded that, the technology import stimulates the domestic R&D at the adaptation stage, therefore have complimentary nature and the accumulation of knowledge created in this way, causes the R&D to get a substitutive position.

Mexican case was analyzed by Blomström (1986). His question is how foreign entry influences the technological structure in the host country industries and whether the relative performance of firms within Mexican manufacturing industries varies systematically with the presence of foreign subsidiaries. Although this perspective is somewhat different, instead of technology transfer Blomström analyzed direct foreign investment. But through the improvements in technological efficiency point of view, with the spillover effects of R&D can be considered to be in the scope, for this reason it worth to refer here. Blomström found a positive correlation between foreign presency and structural efficiency. He found that in the least efficient plant foreign entry is uncorrelated with the changes in technological frontier and in labor productivity, however, for the industry average foreign entry is highly related to productivity changes. He explained this with the "dual" structure of production in the underdeveloped countries. Foreign firms entering the modern sector increase the efficiency there, leaving the traditional sector as they were.

Positive effects of technology transfer in semi-industrialized countries of Latin America have been analyzed by Teitel from Inter-American Development Bank (1984). Teitel mentioned about the adaptive technological change, whose cost can easily be predetermined and whose results are quite certain with respect to the basic research, which has an element of risk of spending a lot without reaching a better allocation of resources. Most of the research studies in Latin American countries are conceptualized to the necessary answers to the bottlenecks that must be removed to accomplish production. Such adaptive technological activities do not concentrate on major innovations but the minor ones.

The evaluations of Teitel (1984) are very close to the situation in glass industry in Turkey. In a similar manner to the above referred countries, Turkey may be a good example for comparison of R&D and technology transfer effects on productivity and analysis of the trigger effect of technology import on domestic R&D. Instead of an analysis over all industries, being among the industries Turkey highly competitive in the world, container glass industry's production, cost, R&D and technology transfer data between 1986-1999 is used in the model for such a comparison.

Şişecam, the monopolist of Turkish glass industry has been spending more and more on R&D projects in recent years, as well as technology purchases with the enforcement of competition in global and domestic market explained in the previous chapters. It can clearly be detected from the data that, in the last 14 years, as technology transfer expenditure decreases, R&D spending increases, well indicating that the analysis of technology transfer and R&D in the above explained manner, taking the market conditions into consideration could be interesting.

5.1 THE MODEL

In the model production is expressed as a function of machinery and equipment assets, research and development expenditures, costs of license agreements for technology transfer and consumption of raw material, energy and labor. Some of these factors are interrelated as well. Between the two typical production functions, Cobb-Douglas and Leontief, form of Cobb Douglas production function is mostly preferred in the literature concentrated as the level of technology and some of the production factors are assumed to be continuously changing.

Şişecam's container glass division has three-glass container production plant in Turkey, and one in Georgia since 1998. The three in Turkey, Anadolu Cam Sanayii A.Ş. (Mersin), with three furnaces; Topkapı Şişe San. A.Ş. Topkapı and Çayırova plants with 4 and 1 furnaces respectively, were taken in to consideration[1]. Time series analysis with GMM (General Method of Moments) in E-views is used.

$$Q=f(RM, E, L, M, R^{*}, T^{*}) \qquad (5.1)$$

R^{*}: Accumulated expenditures on research & development activities ($)

T^{*}: Accumulated fees of agreements for technology transfer from foreign firms ($)

RM: Raw Material to produce glass (tons)

E: Energy consumed in three different plants (st. m^3)

L: Number of labors

M: Machinery and Equipment Assets

Q: Production (tons)

The three plants' production data has been used by summing them up, causing some error in the results, as conditions and fixed costs of each plant and each furnace is different. However, separate data on furnace basis, couldn't be found. Research and Development is an activity followed by holding company, which has separate divisions of Flat Glass, Tableware, Chemicals and Metalworks as well, in its constitution. The technology transfer issue is managed by head quarter of each division. So they are taken as the values in the accounting files for the whole container glass division. Especially for technology transfer, although the service may be on the specifics of one of the plants, it

[1] Anadolu Cam Sanayii A.S., has taken over Topkapı Şişe Sanayii A.Ş., in year 2000.

may not disturb the results considerably, as information is shared among the three plants and adds up to accumulation of technological experience.

For raw material, energy and labor, physcial usages are taken into account. Raw Material is put in to model by tons of annual consumption; energy by standard cubic meters of natural gas used, all over the process (if any other form of energy is used, it is converted to standard cubic meters of natural gas by corresponding calorific values); labor by number of blue collar personnel. Machinery and equipment asset is calculated as $ value and escalated over years. Although new investment in machinery and equipment is referred as a new level of technology generally in economics, technology concept here is different. New machinery and equipment, adds up to technological capabilities, but specifically for science based industries, the know-how necessary to operate the machinery and equipment efficiently is subject of technology transfer and domestic research activities. Mainly data used here as research and development and technology transfer, refers to this know how.

To form R&D and technology transfer data, information received from such activities is simulated by the escalated amount paid in the relevant year, and this information is depreciated by 15% each year, as 15% is the accepted rate of depreciation of information in many studies published on productivity effect of research and technology transfer activities. Technology transfer is represented by the amount that is paid to Heye Glas (German glass and glass production machines producer), in the content of Technical Assistance Agreement between Heye and Şişecam, as accumulated and depreciated by 15% each year. To simplify, both technology transfer and R&D expenses are changed to accumulated data by

$$R^*_i = R_{i-1} * 15\% + R_i \qquad \text{and} \qquad T^*_i = T_{i-1} * 15\% + T_i$$

For each year i, R^* and T^* being accumulated data that is taken in to consideration in the model.

Technology transfer data represents that, the trend of the amount paid for this purpose is decreasing. In 1986 and 1987, such expenses are high, as a new technology named as Narrow Neck Press Blow is transferred from Heye. Due to the lack of familiarity with this new technology, considerable technical assistance seems to be needed, meaning relatively high technical fees in addition to royalty payments for the imported technology. Following this, the payment reduces to the standard fees of the agreement and the payments for the audits. The technology necessitates some problem solving exercises to be adapted to the local conditions and leads to better understanding of the technology with some adaptive R&D costs. Although such R&D costs are relatively small during the first years of major technology transfer, its trend needs analysis. Increase in trend of R&D payments with respect to technology transfer indicates becoming more self reliant in technology. (Katrak, 1985)

From the data it can be followed that, in 14 years time, as compared to technology transfer, research and development expenses gain weight. In Figure 5.1 the horizontal axis is the expenditures on innovative activities. Technology transfer data has a peak in 1998 and a trough in 1994 and seems to remain in a horizontal band, where R&D data has an increasing trend over technology transfer. Here R^*/T^* represents the average propensity to adapt, and $(\Delta R^*/\Delta T^*)$ marginal propensity. Therefore the elasticity of R with respect to T, could be derived by $(\Delta R^*/\Delta T^*)/(R^*/T^*)$. The propensity to R&D could be detected by the trend curve's concave up nature. Data analysis shows that, the elasticity exceeded unity for the last years.

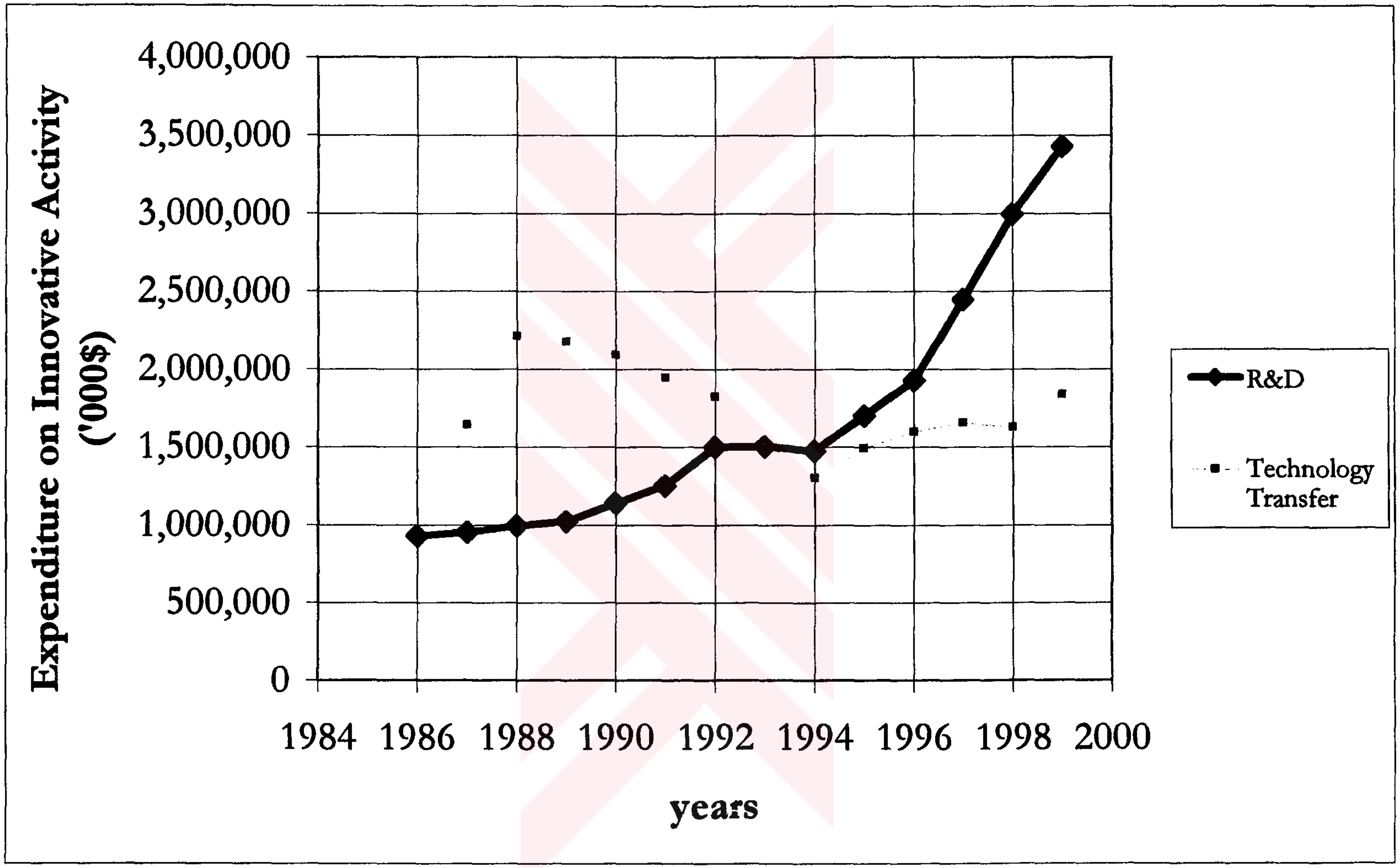


Figure 5-1 Research and Development vs. Technology Transfer

The above graph supports the view of the trigger effect of imported technology on domestic R&D. It can be analyzed from the annual reports of the company that, in time, Şişecam established complicated research facilities becoming more and more self sufficient in technology. Furthermore, began to license its technology to less developed countries like Egypt between 1996-1999, and take part in research consortiums formed by other world giants from developed countries.

Technological capability does not have single characteristic. It can be diverse from setting up of plant to innovative effects, and to quality control. Although industrial economics concentrates on innovative effects, in practice for many sectors the others are as well subject of technology transfers. A firm may be self-reliant in one or more of these aspects. The less complex aspects of technology, can normally be assimilated more readily, while the more complex characteristics may continue to be imported. (Katrak, 1985) Şişecam's self reliance on technology can be classified as sufficient to set up and operate new plants with the most modern technology, even export this technology to less developed countries. However, as it can be followed by the data, it still continues to be an importer of technology.

On innovative R&D arena, there is no major development Şişecam has been engaged in during these years, although took place in some global research consortiums. This may be based on complexity of the science-based glass production industry. As technologies become complex, firms' tendency towards R&D consortiums increases, which is valid for Şişecam as well. For such major development a passive approach has been adopted. Tendency is towards to take place in a research consortium, or to wait and follow development of technology, prepare means to make transfer at as low cost as possible, and to make transfer agreement at reasonable cost. If the cost is not reasonable for transfer, imitative research gains weight as well.

Şişecam's arising technology addiction during the recent years can be easily linked to the market conditions explained before. Cutthroat competition created by the substitutive goods becoming more and more strong, in addition to removed barriers to import, forced the monopolist to take some measures, both on price-cost and quality sides. Above analyzed developments helped to protect its world giant position, even compete with glass producers of developed countries in their home markets with most developed technologies, either transferred or self developed.

As glass production and carrying out research in this area needs strong financial power, Şişecam's monopoly position can be considered as an advantage for engagement in R&D. To compare the level of incentive and means for innovative projects referring to Schumpeter's ideas, "There are superior methods available to a monopolist which are not available at all to a crowd of competitors or are not available to them so readily: for there are advantages which though not strictly unattainable on the level of enterprise as a matter of fact secured only on the monopoly level, for instance, because monopolization may increase the sphere of influence of the better, and decrease the influence of the inferior, brains, or because the monopoly enjoys a disproportionately higher financial standing….." (Waldmen, Jensen, 1998, p: 345-6), it can be verified that, Şişecam has the financial power of a monopolist for research, in addition to the incentive created with the above explained facts. In their model, Waldmen and Jensen described the perfect competition as the type of market having the highest incentive for technology improvement but lowest ability due to normal profits; oligopoly as a market having respectively higher profits and high incentive, where dominant firm as the type having the highest financial power with moderate incentive. In the light of the market characteristics explained in Chapter 3 as the expenditures on innovative processes, either through R&D or technology purchase, are analyzed year by year in the model, it is possible to detect incentive through Şişecam's point of view.

To compete with both imported glass and substitutive goods, cost concept is of course the focus of Şişecam's consideration. Therefore, productive effects of both technology transfer and R&D need to be compared. In the light of above information and the sector data, the following function is obtained;

$$Q=6,417\ RM^{0.379}\ E^{-0.074}\ L^{0.486}\ M^{0.042}\ R^{0,248}\ T^{-0.076} \quad (5.2)$$

	Coefficient	Std. Error	t – Statistic
RM (Raw Material)	0,379	0,033	11,445
E (Energy)	-0,074	0,019	-3,866
L (Labor)	0,486	0,185	2,623
M (Machinery and Equipment)	0,042	0,011	3,547
R (Research & Development)	0,248	0,070	3,536
T (Technology Transfer)	-0,076	0,032	-2,387
C – (ln of Constant term)	1,859	1,863	0,998

R^2: 0,977; Adjusted R^2: 0,959; Durbin Watson: 2.833;
Std. error of regression: 0.0588 Mean Dep. Variable: 12,587;
Akaike info criterion: -5.358; J-Statistic: 2,52E-21; Schwarz Criterion: -5.039;

Statistical results indicate that, energy and technology transfer have negative effect, on the other hand, raw material, labor, machinery and equipment and research & development activities have positive effect on productivity. All coefficients sum up to

1,004, indicating constant to increasing (almost constant) returns to scale. As scale economies is valid in the industry, and as the first investment costs of plants are high, investment decision is practically taken after the demand in the market reaches an acceptable level. This may correspond to a point on the right of the minimum of the short run average cost curve, as shown by point X in Figure 5.2, and on the left of the next coming short-run average cost curve. Therefore, following the opium point of production, returns to scale of the factors of production may fall, till the next coming investment's optimum point of production. Although, the sum of the coefficients are still higher than 1, if older data could have been found, scale economies would have been more apparently presented.

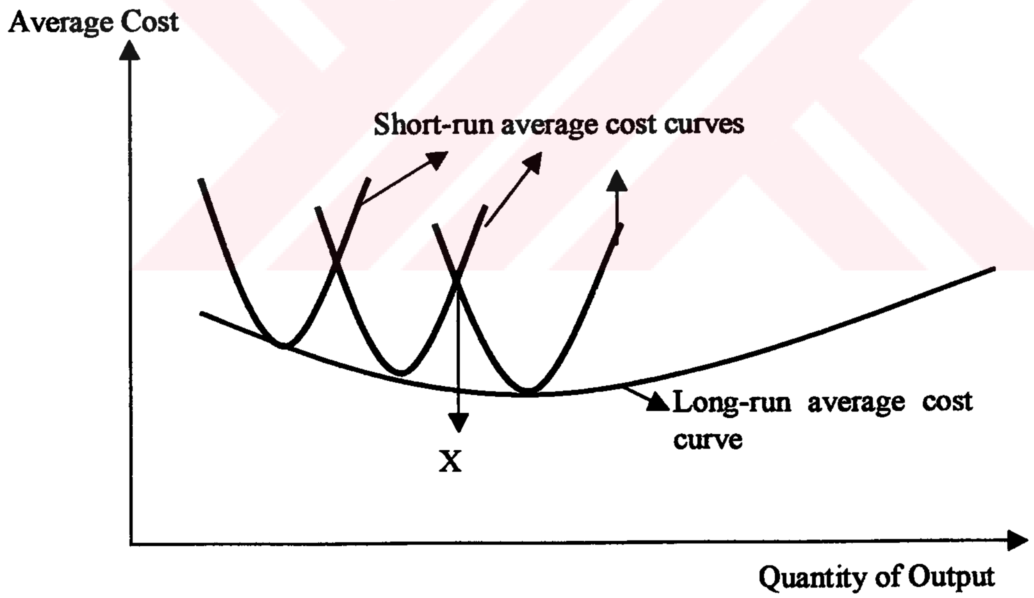


Figure 5-2 Long-run and short-run average cost curves

Except the constant term, absolute value of t-Statistic of all parameters' exceed 2, indicating that the relevant parameter's coefficient is at least 95 percent likely, not zero, R^2 is very close to one, measuring the success of the regression in predicting the values of the dependent variable within the sample, in addition to the Durbin Watson above 2, which would, if not, be an evidence of positive serial correlation.

Using the above result change in production both with research activities and technology transfer over years can be calculated by taking derivative of the Cobb-Douglas production function according to R and T respectively.

$$DQ'/DR = 1.591 * RM^{0.379} E^{-0.074} L^{0.486} M^{.042} R^{-0,752} T^{-0.076} \quad (5.4)$$

$$DQ'/DT = -0.488 * RM^{0.379} E^{-0.074} L^{0.486} M^{.042} R^{0,248} T^{-1.076} \quad (5.5)$$

Data calculated from (5.4) and (5.5) are plotted for comparison in Fig. 5.3.

Derivative of Cobb-Douglas Production function according to technology transfer as stated in (5.5), is negative due to the negative power coefficient of technology transfer in production function. Its meaning may need explanation. Expenditures on technology transfer decreased over years, leaving room for domestic research. Despite this reduction, amount of production kept rising, which causes the derivative in (5.5) to be negative.

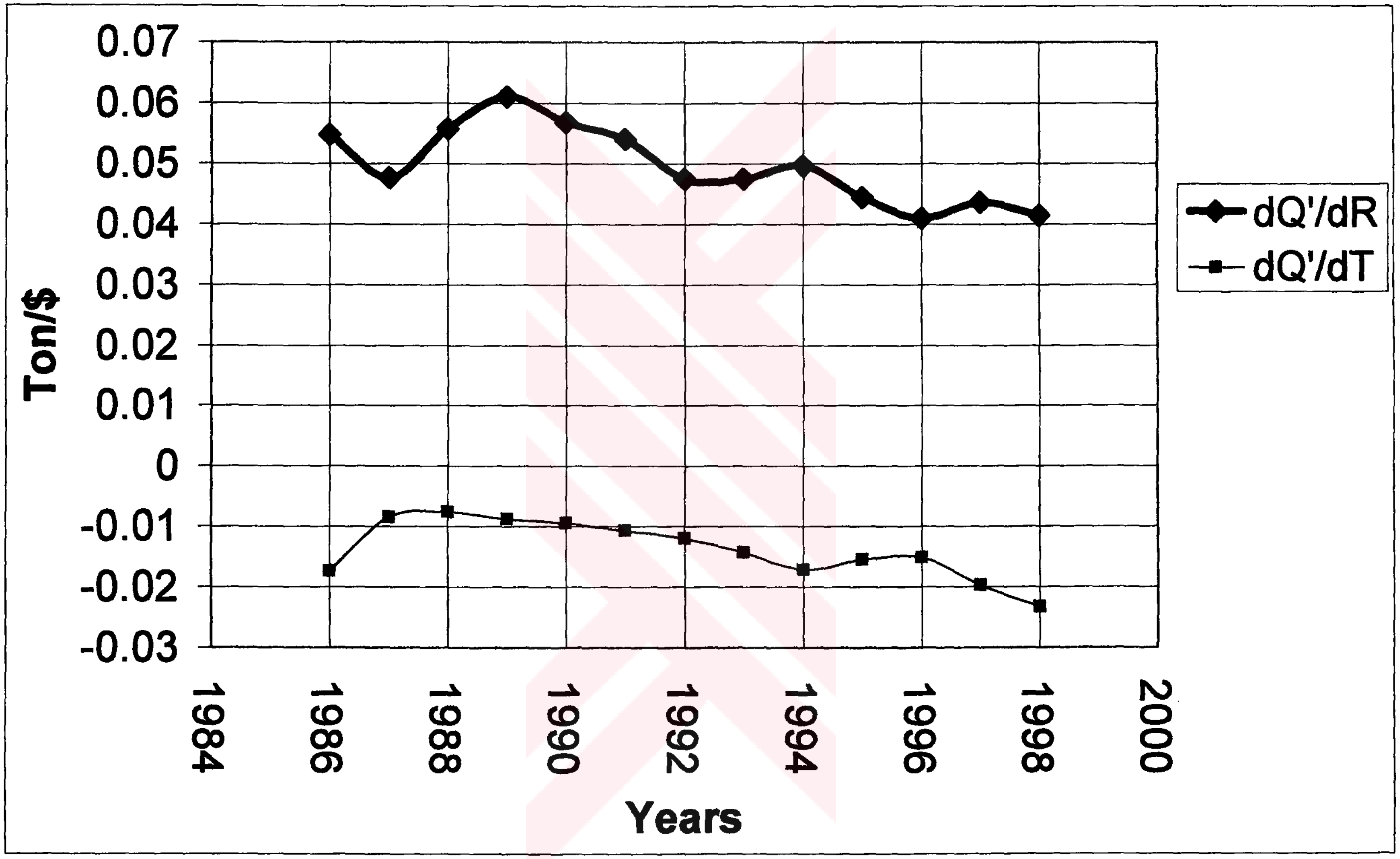


Figure 5.3 Comparison of productivity gain per 1$ spent on Research and Technology Transfer

5.2 RESULTS

Results clearly highlight that the effect of technology transfer on productivity is slightly negative. This can be explained by the fact that technology agreement between Şişecam and Heye turns out to be a series of audits and information sharing media since 1989. As it was stated in the beginning, a new technology licensed to Heye was transferred in 1986 and 1987. However, this technology was to reduce the weight of each article, keeping its strength constant by improving the glass homogeneity through out the article and to get a better view. Therefore, this has something to do with the number of bottles, not with the tonnage pulled from the furnaces. However, number of bottles is not a collected data through out these years and not a correct item to place in such a model as it highly sensitive on market conditions and there is no parameter of market condition in the model. On the other hand, as explained, the adaptive R&D coinciding this technology import helps to reduce unit costs, although it cannot be expressed as a quantitative benefit gained on technology transfer account in the model.

It can be followed in Figures 5.4 till 5.11 that, as there are negative power coefficients in the production function, we can conclude that the production is not at its optimum level. There is decreasing returns to scale on energy. Therefore it is not possible to pass to the cost function, which is the dual of optimum production function.

It should be noted that, all average expenditures are converted to $ values, using the exchange rate between Turkish Lira and US$ of corresponding year. Dirty float over these years causes error in analysis.

When we analyze the effects of R&D and technology transfer on productivity of each cost item separately, we cannot see any obvious trend in raw material or energy. On the other hand productivity of labor shows a clear increasing trend as both R&D and technology transfer activities gain weight. The opposite is valid for machinery and equipment. Productivity of machinery decreases over years.

For raw material, there is a fixed ratio between the tonnage pulled and the raw material fed, changing with the cullet percentage used. As the percentage of cullet increases, the raw material ratio to net output, decreases. This cullet used may be coming either from the plant, as rejected glass, or out of plant, where in plant cullet is not considered among the raw material costs. In other words, it is not meaningful to analyze raw material productivity change with innovative activity. Plotted data is given anyway.

For the energy, on the other hand, as explained in the glass sector chapter, investments in glass industry, as in all of the heavy industries are made for large capacities, taking the steady increase in demand into consideration. This means that, there are cyclic shortages in supply of glass. During the shortage periods, the prices increase naturally, on the contrary, just following the completion of investment, excess supply causes the prices to fall and the stocks to increase. In case a market recession coincides with the excess supply period, normally cost comparison is made between keeping excess stock and feeding glass to fusion again without production. If the production is stopped, keeping the furnace hot without production, causes unit energy cost increase. Besides, percentage of cullet usage mentioned in the above paragraph has an important effect on energy consumption. As the percentage increases, energy needed decreases. It can be followed from the graphs, the peaks of raw material and troughs of energy coincides and vice versa. This can be an explanation for the unexpected trend of the energy data, besides the noise the data has.

Productivity of machinery and equipment seems decreasing sharply over the years of analysis. Basically to be able to compete with the substitutive goods, PET and metal can, which are much more lighter than glass, innovative activities are mostly directed to reduce weight of each glass container, keeping its strength same, that can be achieved by investing in the most modern machinery technology. Therefore the number of units produced with the same ton of glass is higher compared to past, which is a result of the technology transfer during the years 1987 and 1988 and the adaptive R&D in consecutive years. Keeping in mind the demand in market being based on the number of units and machinery speed limitations on the number of containers per minute, by tonnage trend of machinery productivity, which is an element of Fixed Asset productivity and innovative productivity being unexpectedly in parallel can be explained. For the same reason, the raw material spent per container decreases, although the number of units sold increases; however this shows itself in the reverse mode, as we analyze the tonnage produced.

Labor productivity, on the contrary of the other parameters, represents an apparent relationship with each innovative activity, in an expected manner. As spending per ton on any of the innovative activity increases, net ton of production made per person increases as well.

Plotted data of marginal productivity each parameter separately with marginal productivity of R&D and technology transfer could be followed from Figures 5.4 to 5.11. In these Figures, left axis indicates production per physical consumption of that specific cost item. Right axis, (to keep the units same as we take derivative of Cobb-Douglas production function for each innovative activity) indicates productivity of each innovative activity. As long as there is no major innovation, productivity of innovative activity may be understand to get weakened, which is the case here.. This can be interpreted that expenditure of innovative activity per ton of production increases. That is to say, the right axis is the reciprocal of change in innovative activity per ton of production. It should be expected according to theory, as derivative of production for innovative expenditure decreases, meaning innovative expenditure per ton increases, productivity of physical cost item in question should increase as well. Therefore we expect an opposing trend in graphs.

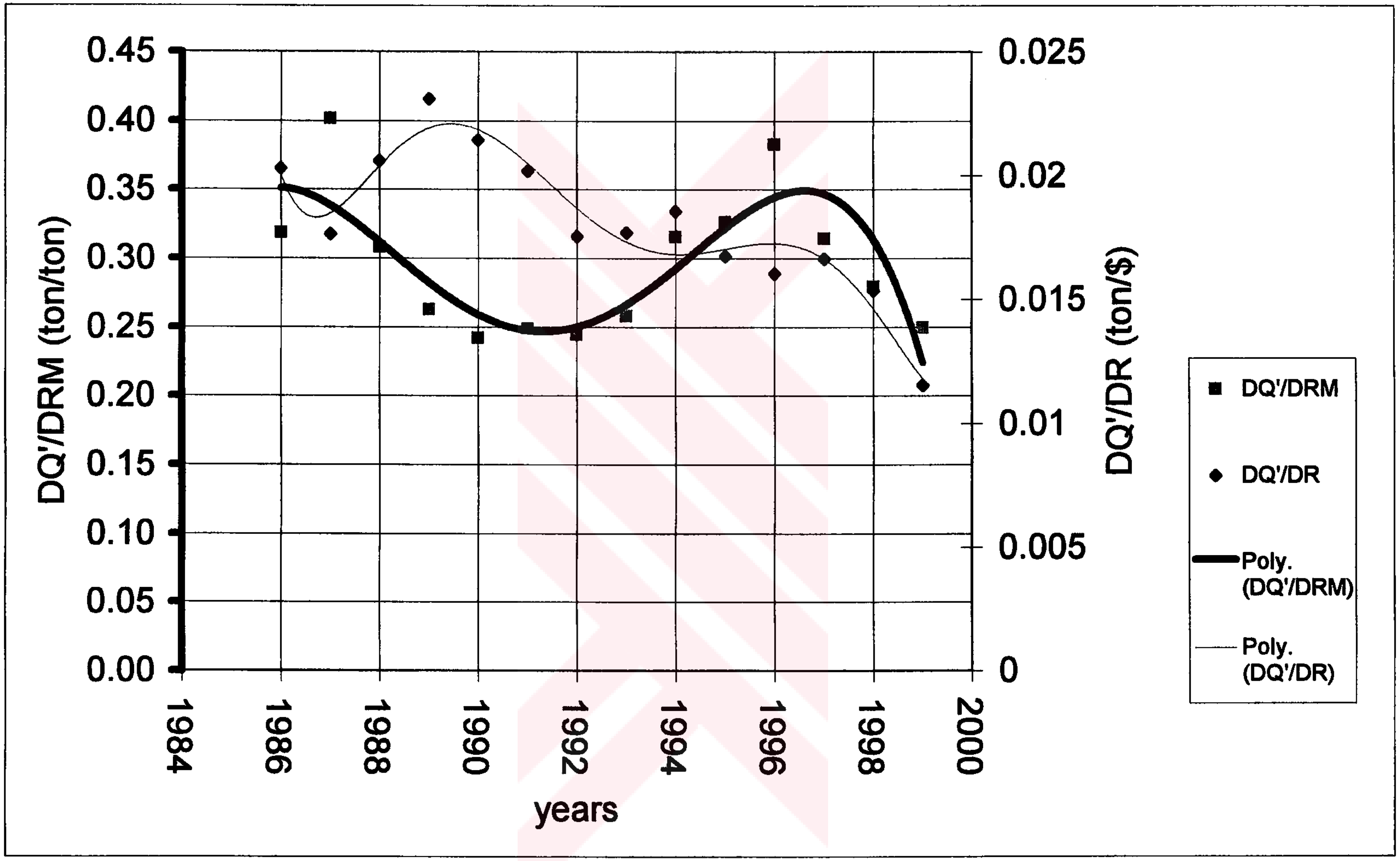


Figure 5-4 Comparison of marginal productivity of Research and Development (R) with marginal productivity of Raw Material (RM)

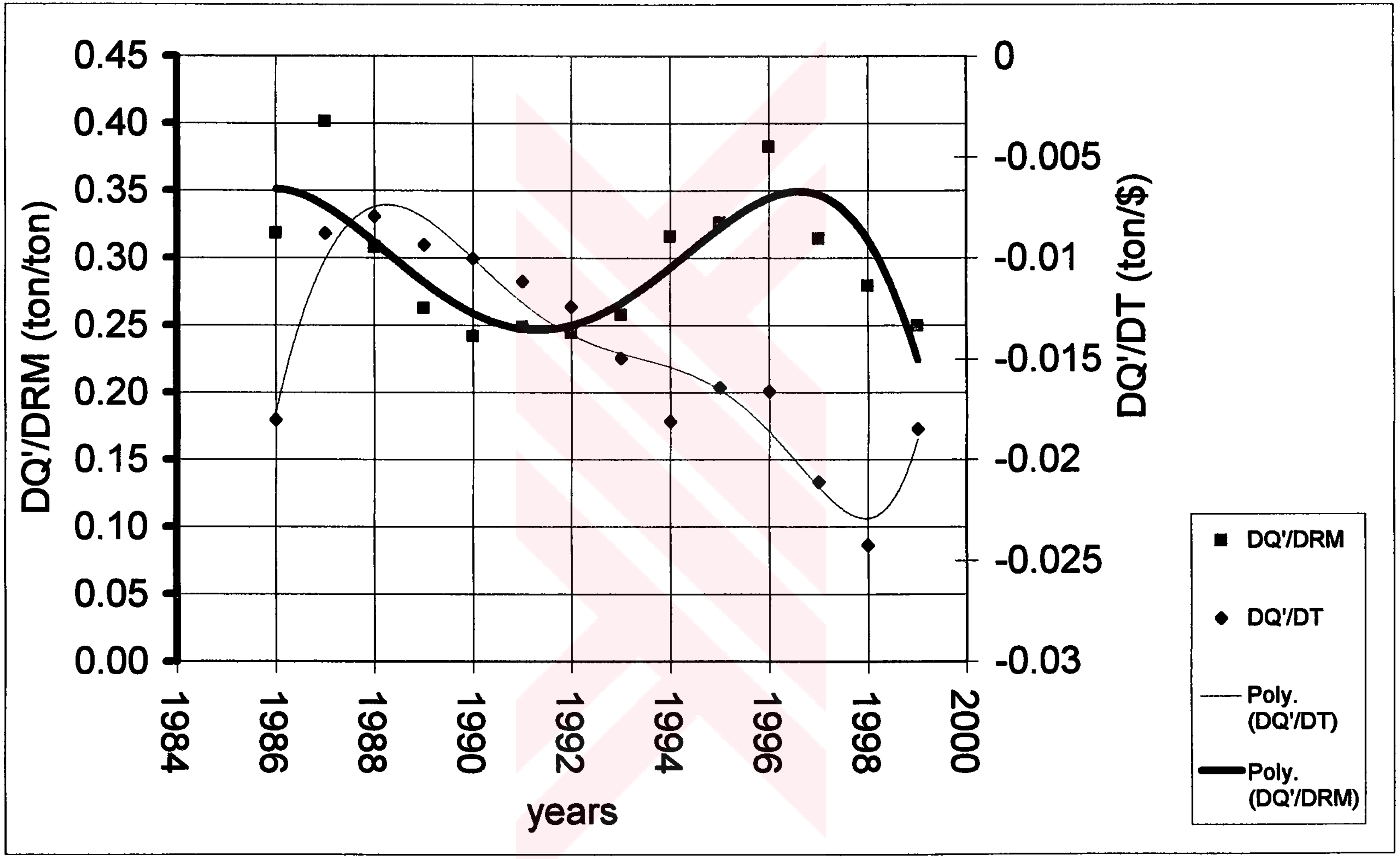


Figure 5-5 Comparison of marginal productivity of Technology Transfer (T) with marginal productivity of Raw Material (RM)

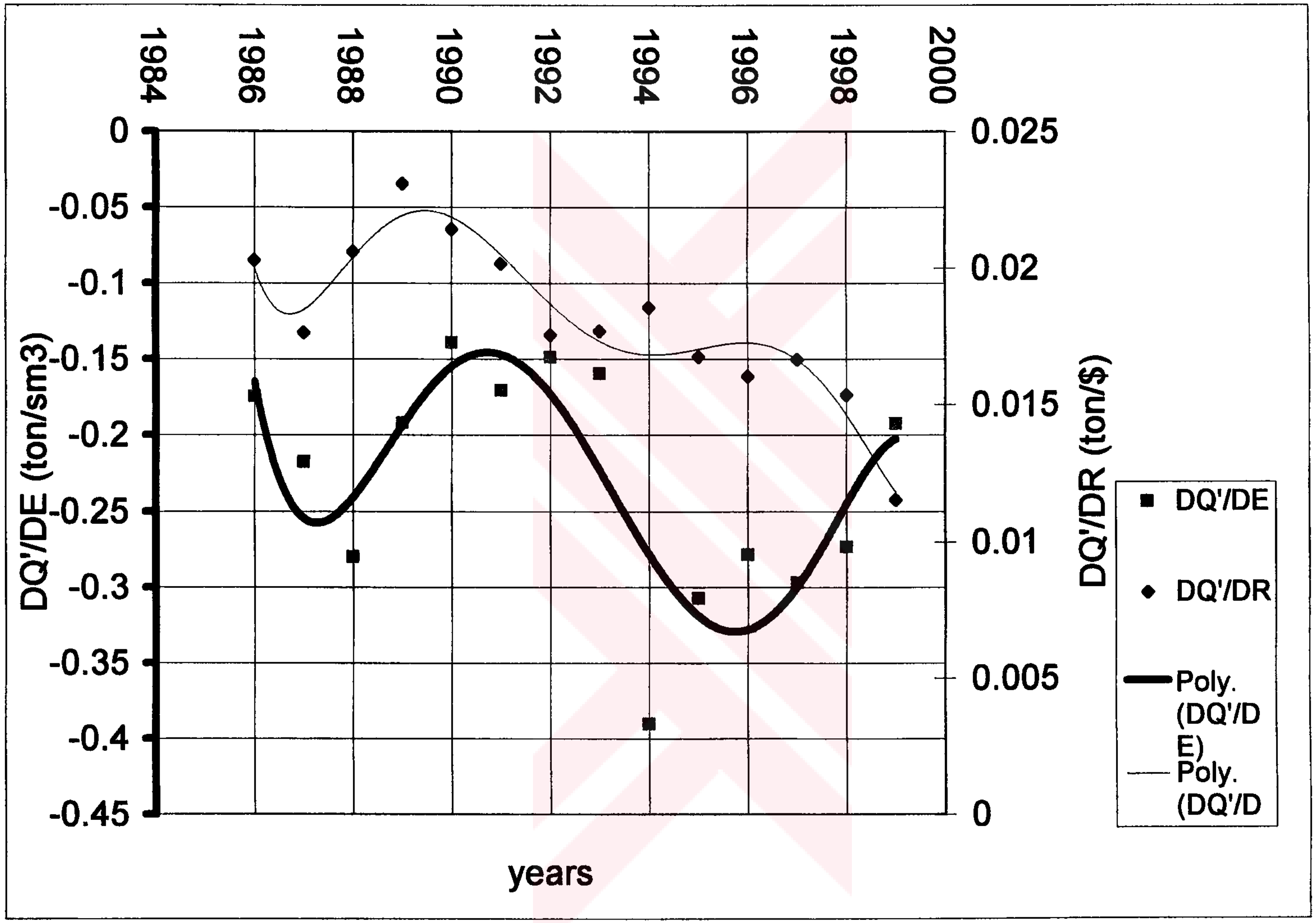


Figure 5-6 Comparison of marginal productivity of Research Development (R) with marginal productivity of Energy (E)

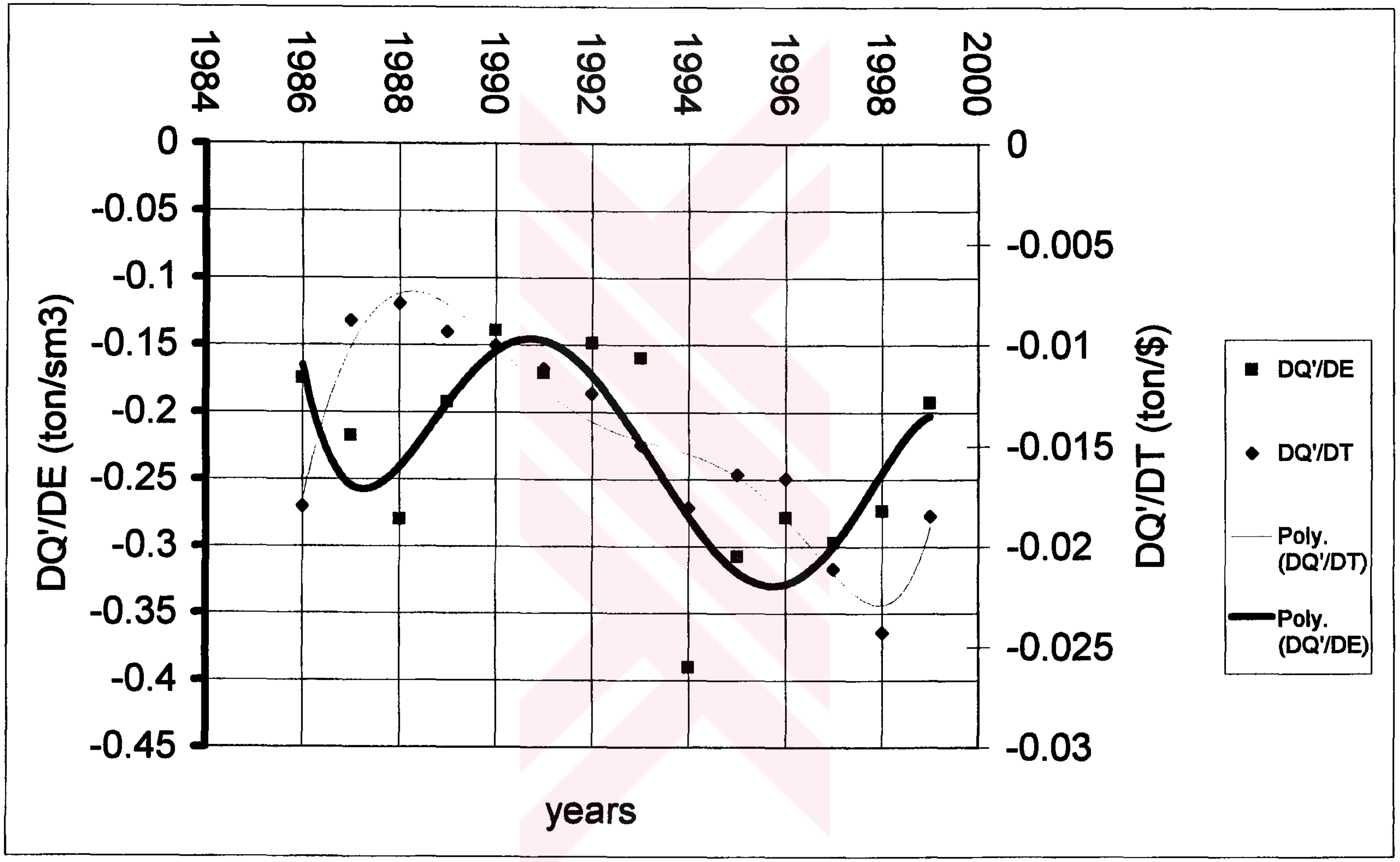


Figure 5-7 Comparison of marginal productivity of Technology Transfer (T) and marginal productivity of Energy (E)

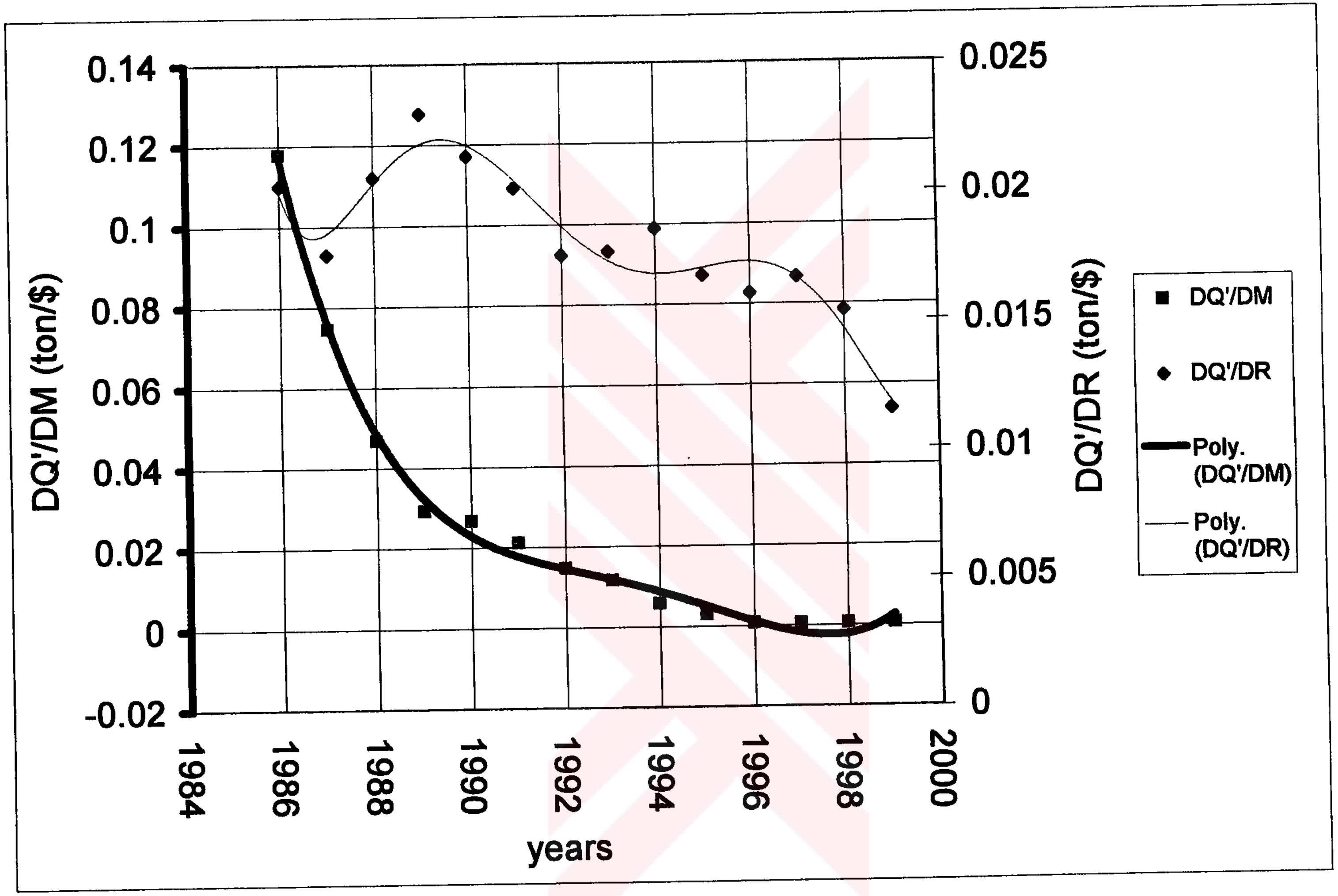


Figure 5-8 Comparison of marginal productivity of Research Development (R) with marginal productivity of Machinary and Equipment assets (M)

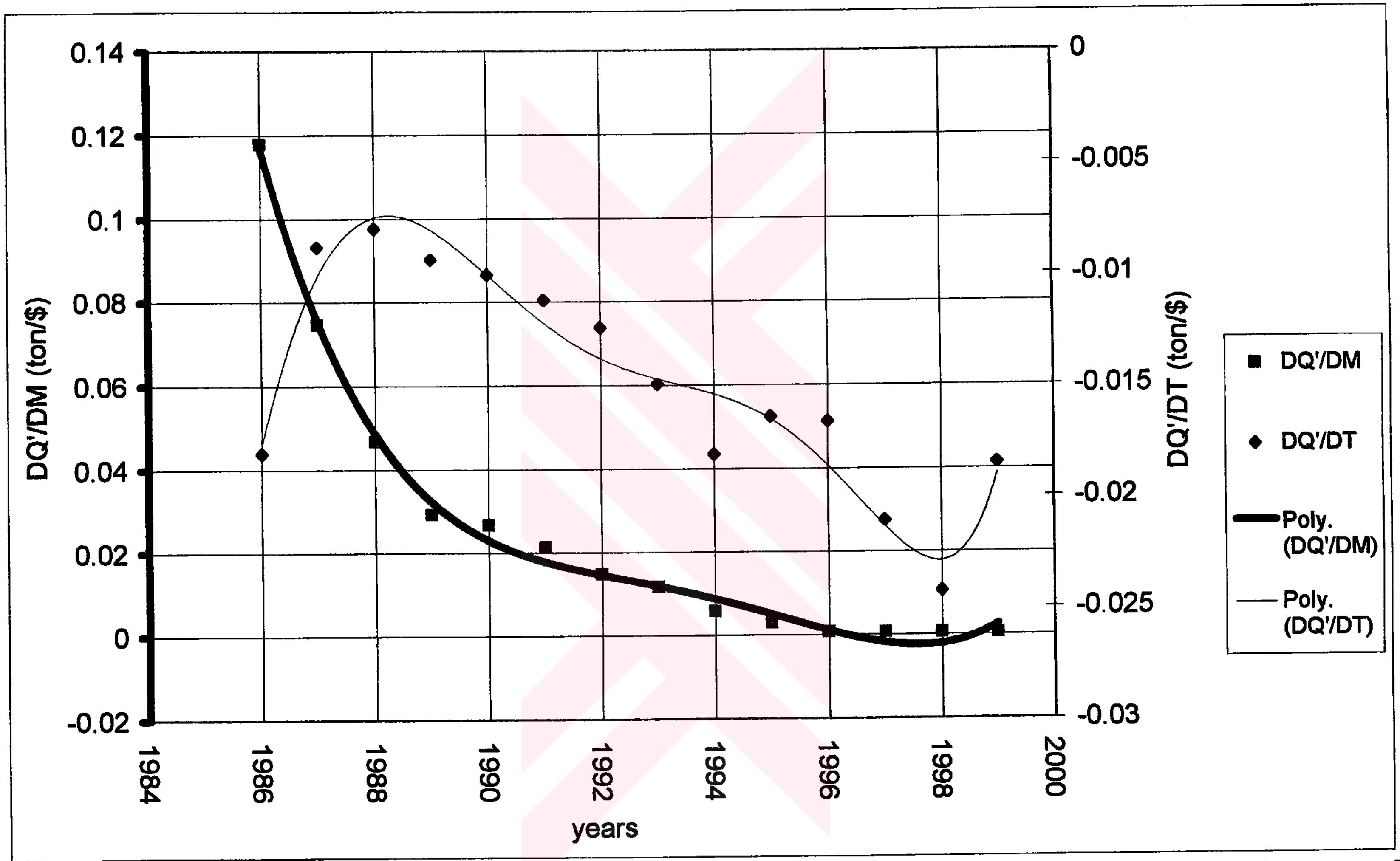


Figure 5-9 Comparison of marginal productivity of Technology Transfer (T) with marginal productivity of Machinary and Equipment assets (M).

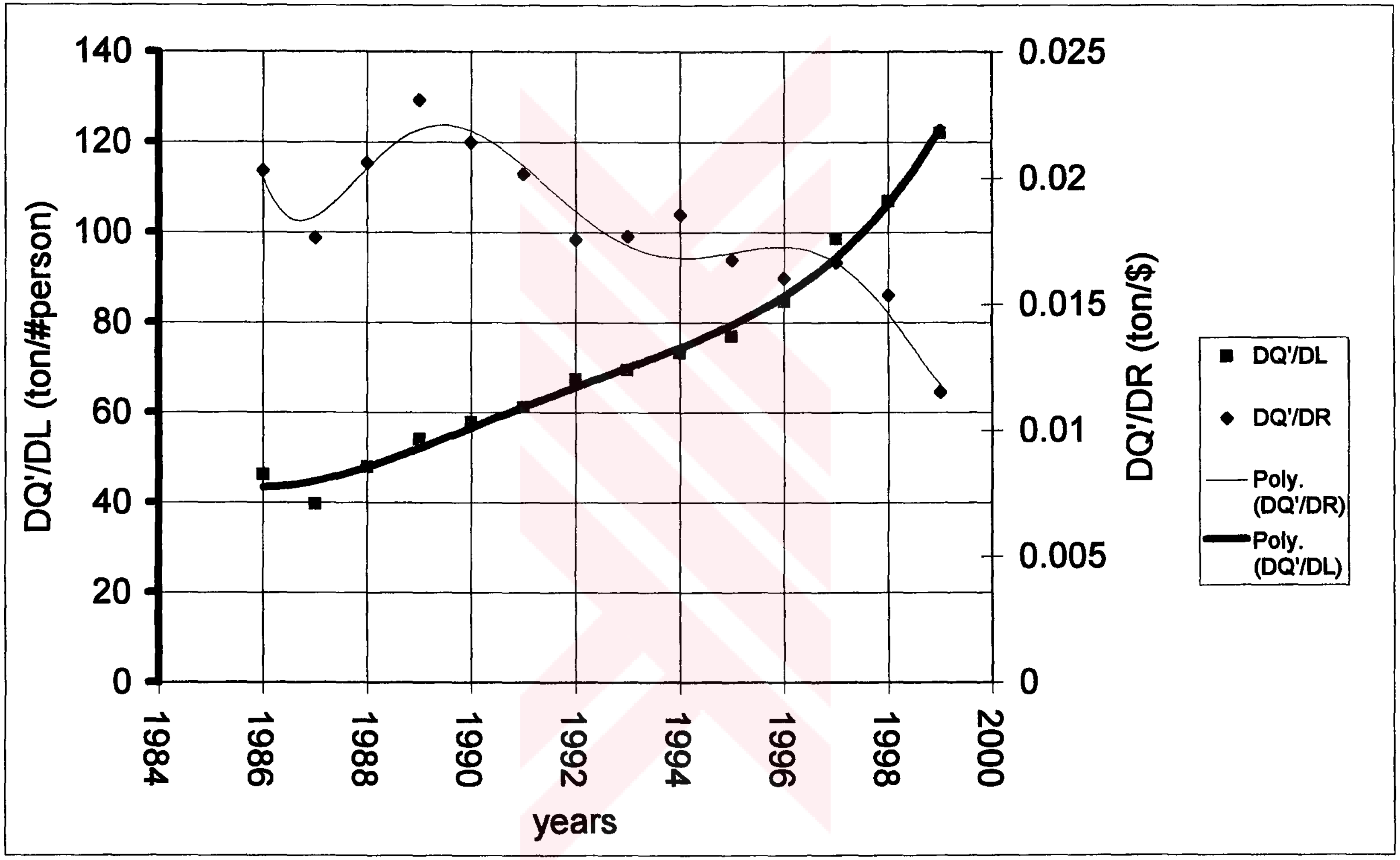


Figure 5-10 Marginal productivity of Research Development (R) with marginal productivity of Labor (L)

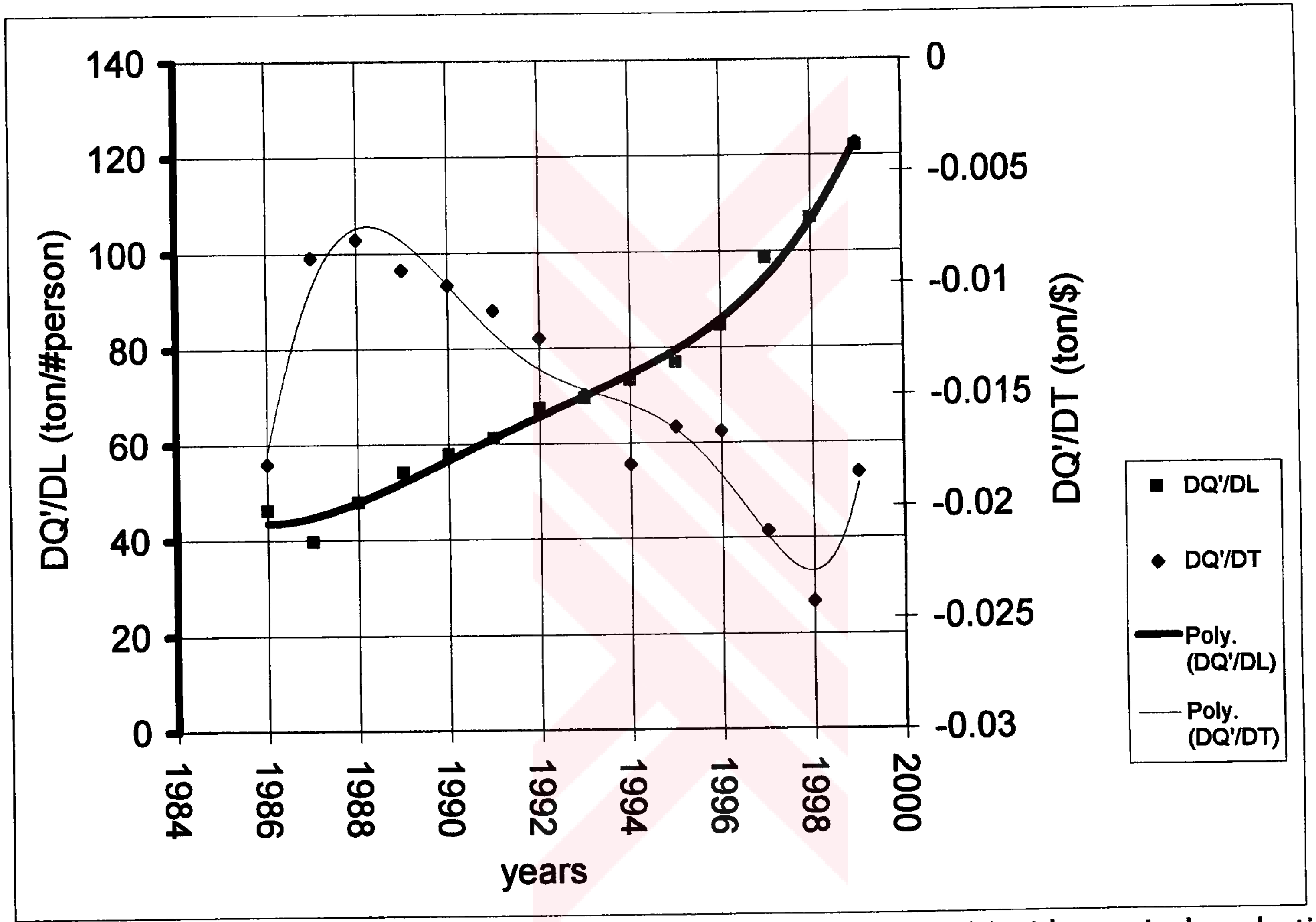


Figure 5-11 Comparison of marginal productivity of Technology Transfer (T) with marginal productivity of Labor (L).

Comparative effects of R&D and technology transfer on the average variable costs[3], average total costs[4] can be seen in Figure 5.12 till 5.15 respectively. Figures should be analyzed according to the units indicated next to each axis. Left axis represents the cost of one-ton net production and the right axis represents change in production with innovative activity or reciprocal of change in innovative activity per ton of net production (as it was stated before, to keep the units same, derivative of Cobb-Douglas production function is taken for innovative activity). Therefore, it should be expected according to theory, as reciprocal of innovative expenditure per ton of production decreases, cost per ton should decrease as well.

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[3] Average variable cost is calculated by raw material, energy and packaging costs. Labor cost is excluded, as the labor union is highly strong and production lines are fully automated.

[4] Total costs are calculated by adding sales, financial, labor, other (due to contracted services) costs, and depreciation in to account. Costs of R&D and technology transfer are excluded.

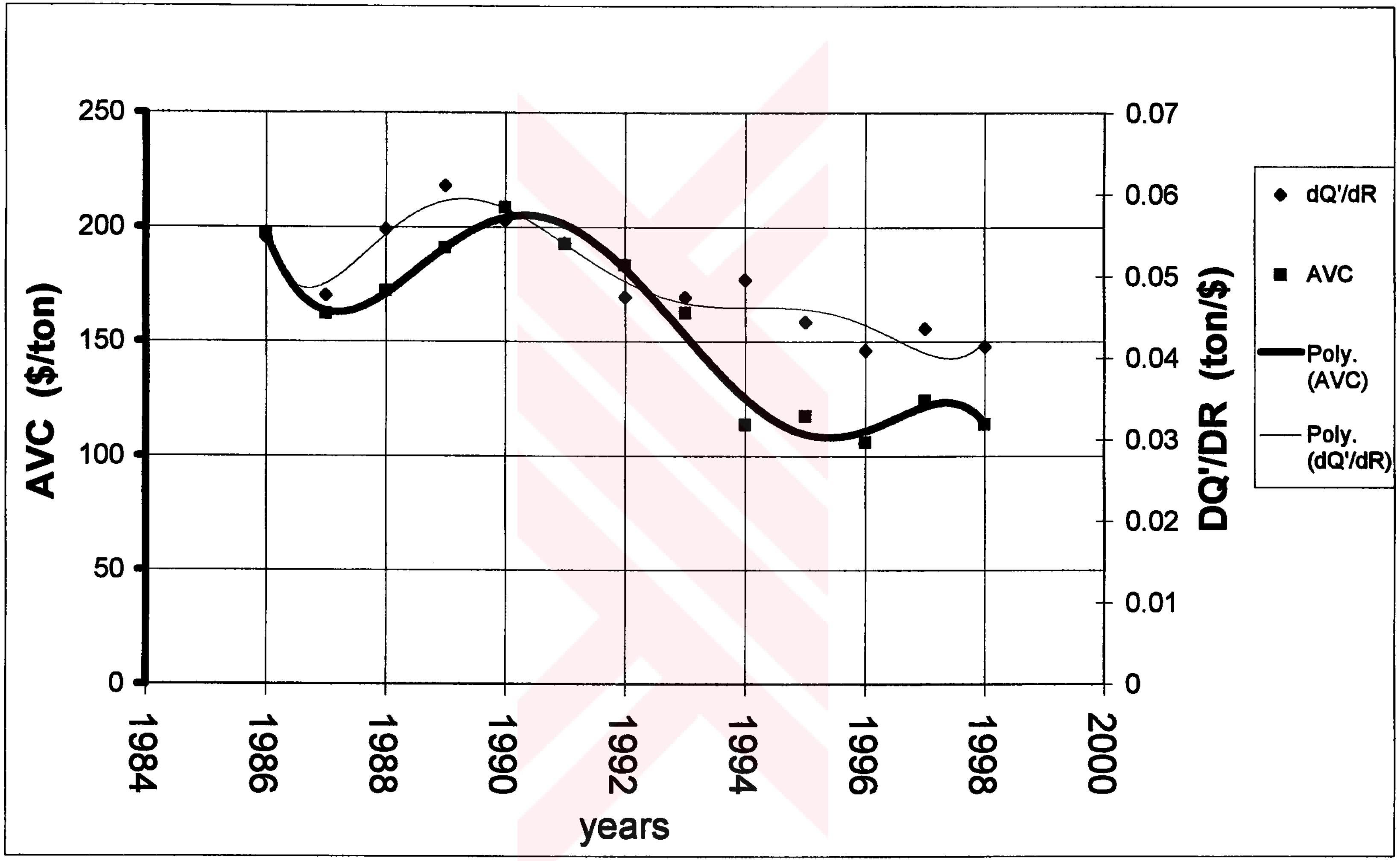


Figure 5-12 Comparison of marginal productivity of Research and Development (R) with average variable cost (AVC).

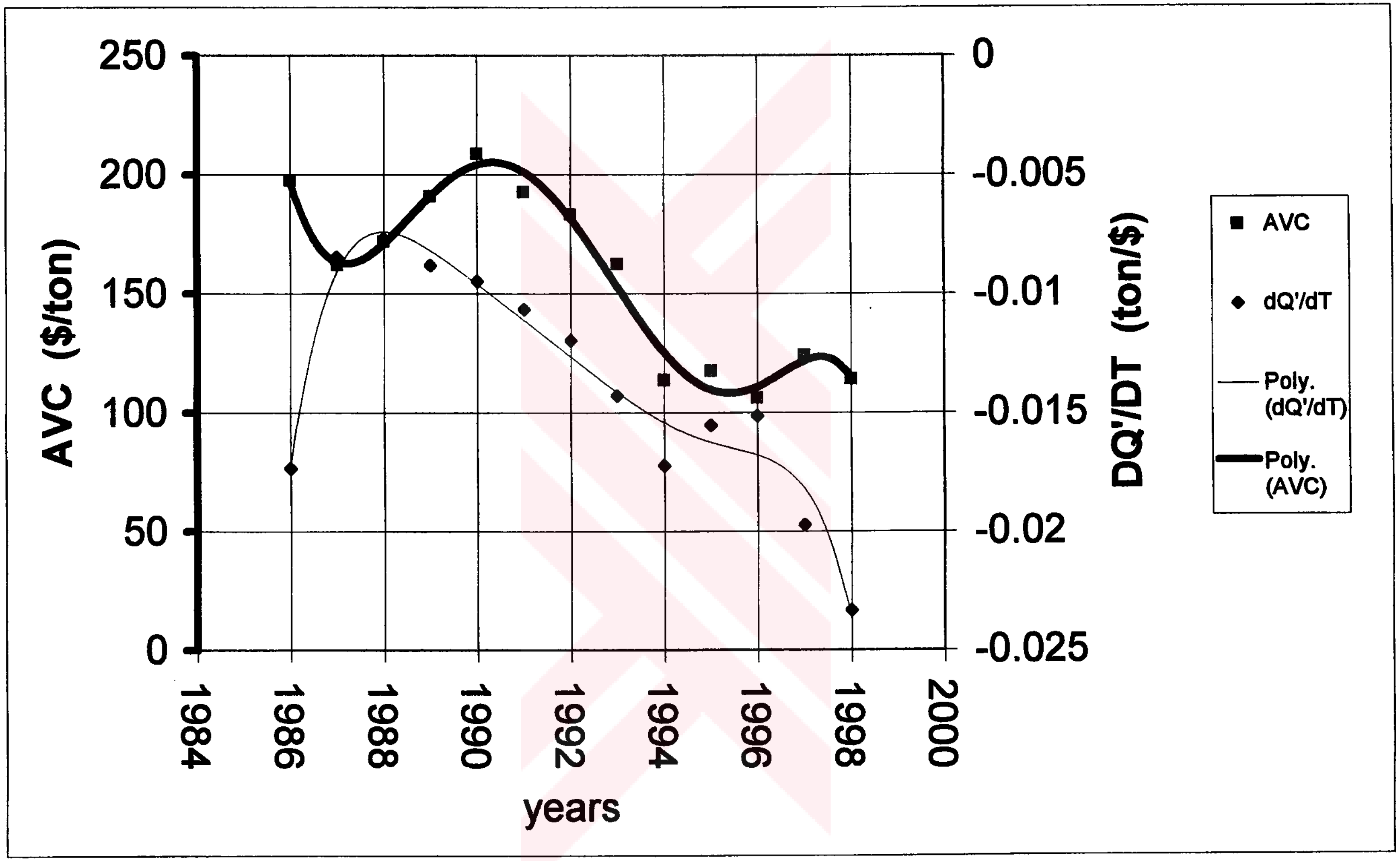


Figure 5-13 Comparison of marginal productivity of Technology Transfer (T) with Average Variable Cost (AVC).

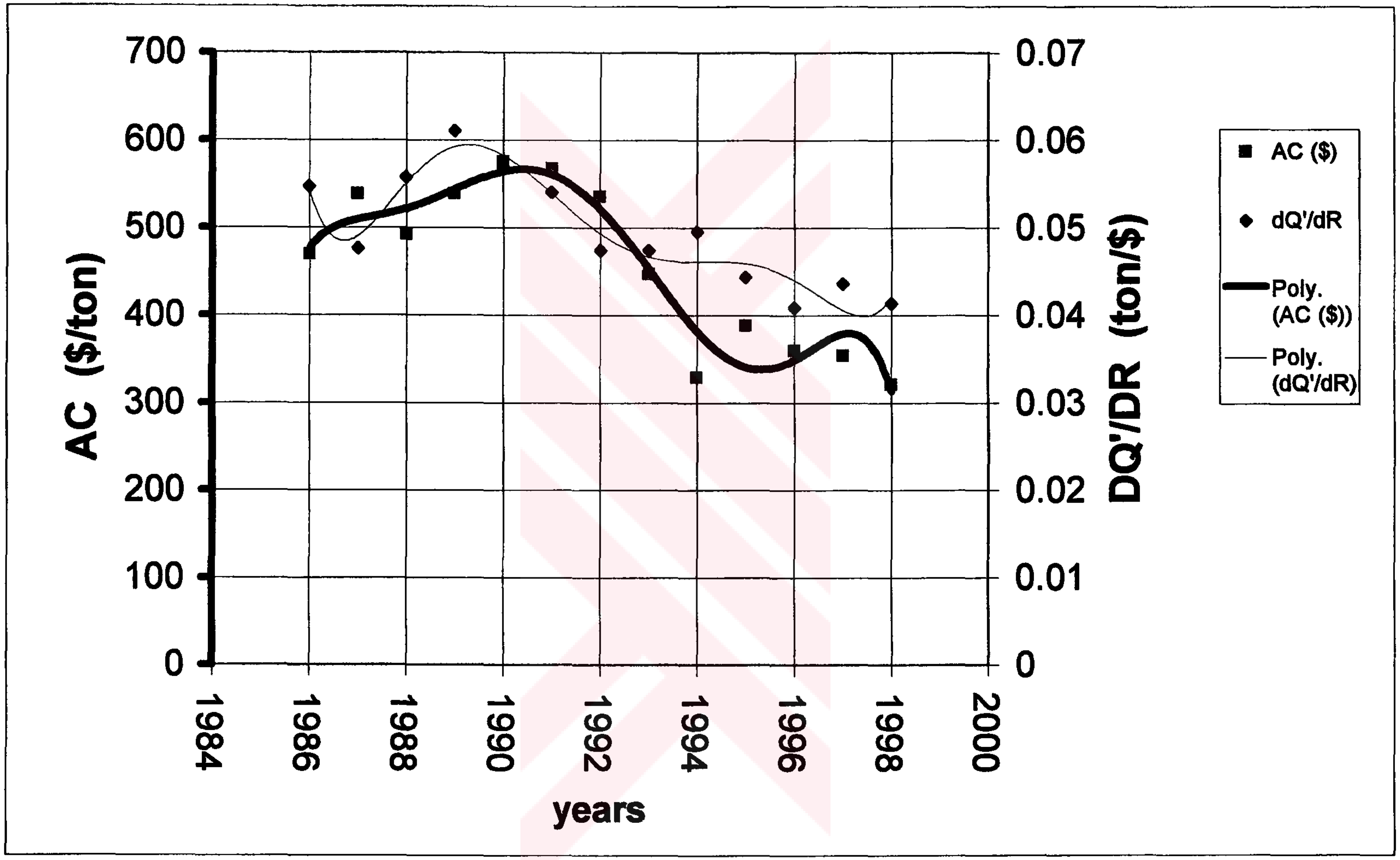


Figure 5-14 Comparison of marginal productivity of Research and Development (R) and Average Cost (AC).

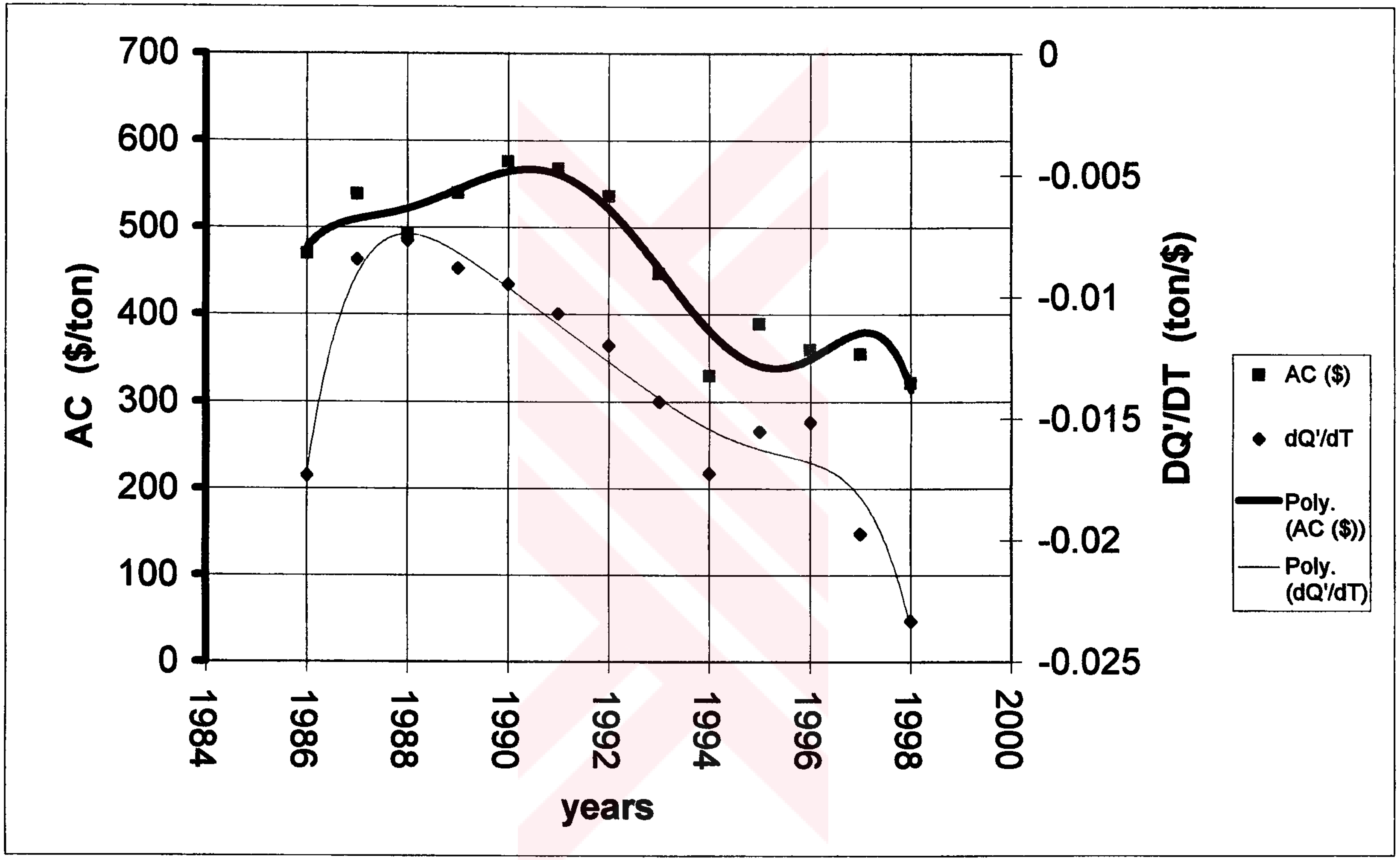


Figure 5-15 Comparison of marginal productivity of Technology Transfer (T) and Average Cost (AC).

It can be detected from the Figures 5.12 to 5.15 the trend is clearly similar showing the positive effects of R&D and technology transfer on the average and average variable costs. Especially for average cost, there seems a gap to exist in between. However, data is not sufficient to run the regression with lag. On the technology transfer figures (Fig. 5.13 and Fig. 5.15), although the shape of the graph is not as smooth as R&D case, similarly downwards trend appears. Such disturbances may be due to the maneuver taken to adapt to the market conditions, as well as noise in data.

As the firm in question has dominant power, pricing policy it applies, with decreasing costs due to both technology import and R&D also needs analysis. Here, technology import costs and R&D expenditures are added up each other and the expenditure on innovative activity per ton, is plotted with average variable cost and price in Fig. 5.16 and with average cost and price in Fig. 5.17.

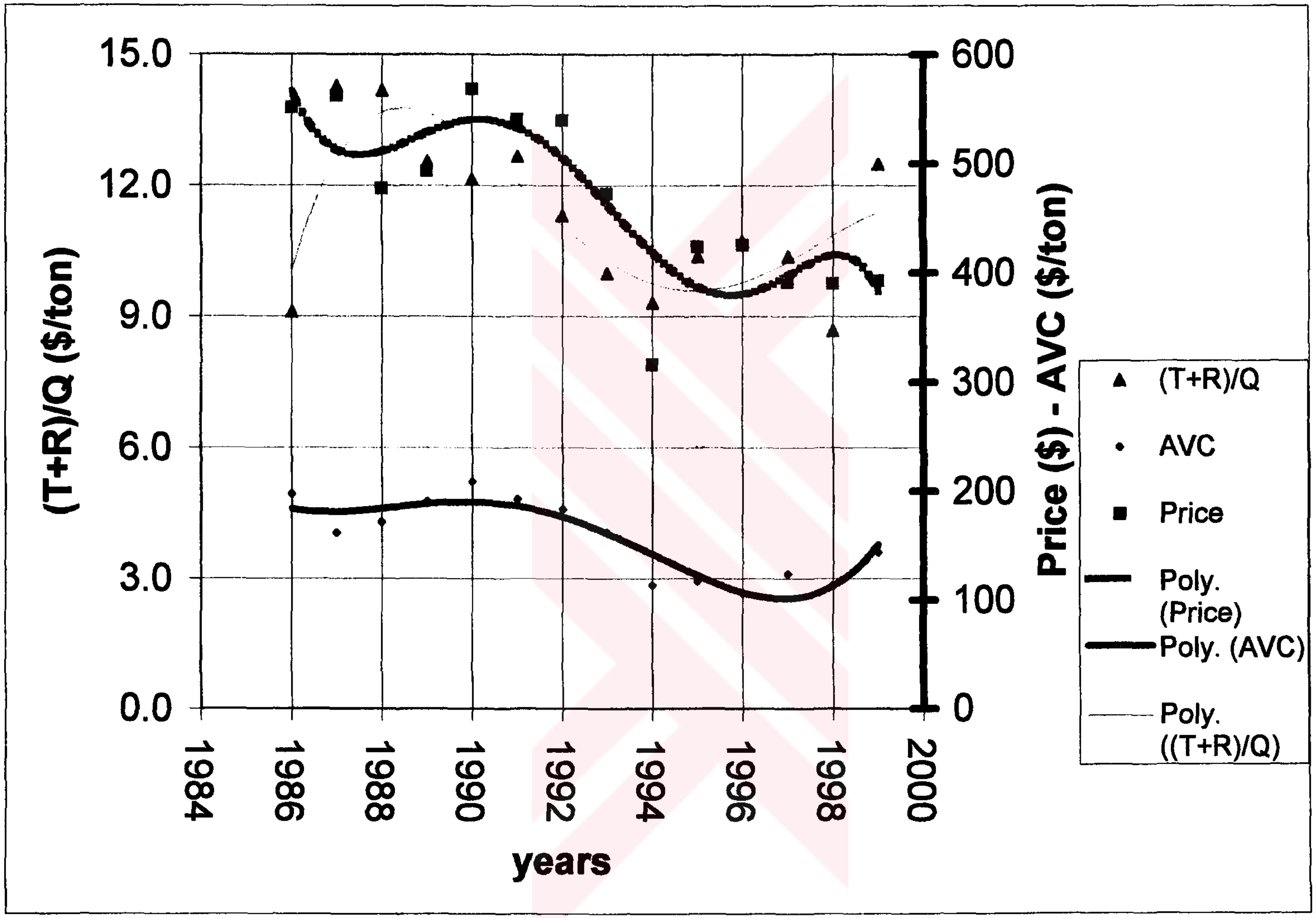


Figure 5-16 Price, Average Variable Cost (AVC) and innovative activity (R+T) per ton of Production (Q).

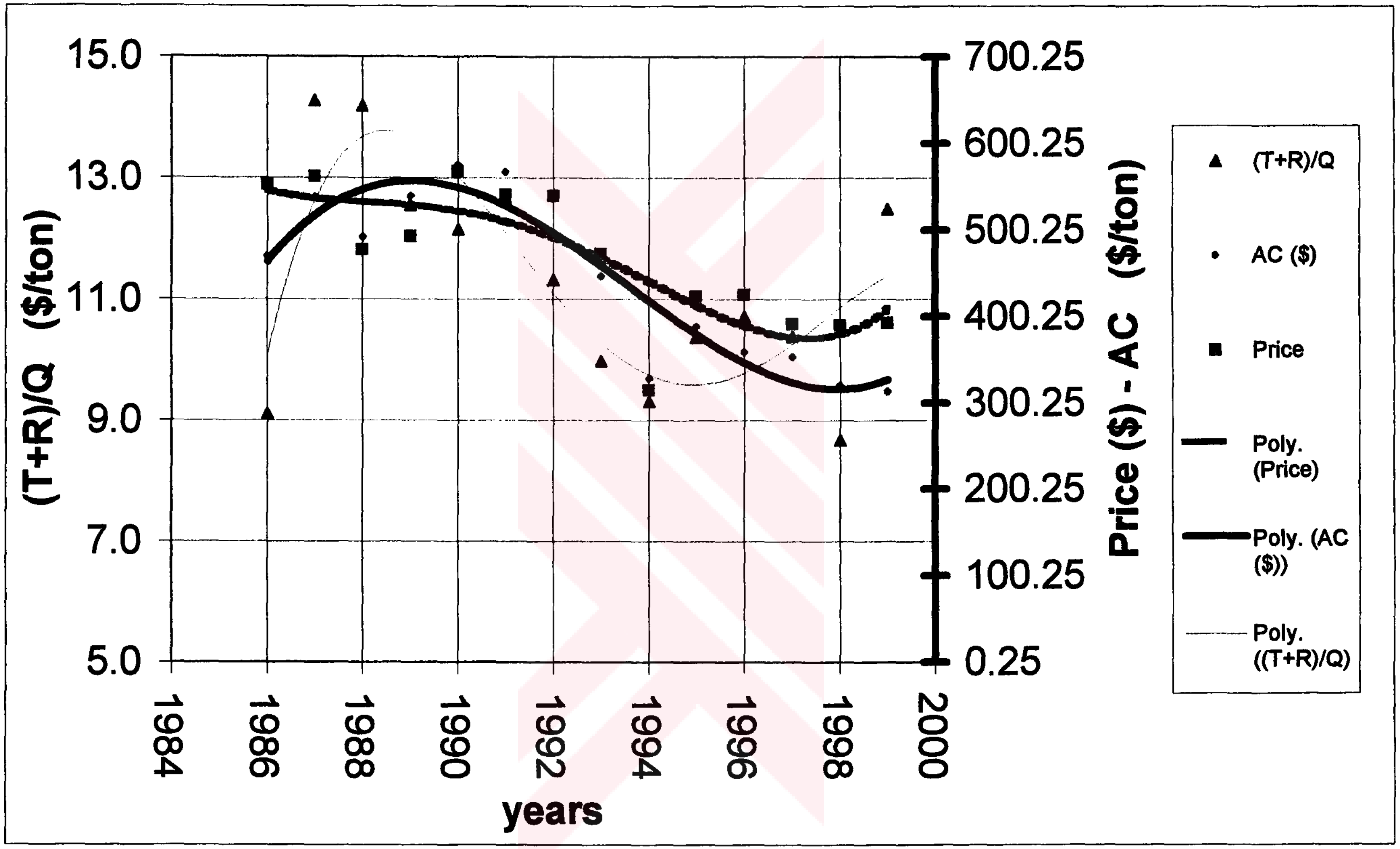


Figure 5-17 Price, Average Cost (AC) and innovative activity (R+T) per ton of Production (Q).

It can be detected both in Fig. 5.16 and in Fig. 5.17 the same parameter with average cost that, although average cost decreases with innovative activities, price seems to float in the same band, determined by the cyclic supply-demand conditions. Price sometimes goes below average costs. Remembering the figure of the "Typical investment point" in Chapter 3 here once more in Fig. 5.18, it may be necessary to show how supply exceeds demand time to time, to meet the increasing demand in the following years, keeping in mind the effectiveness of high capacity investment to optimize the operating and engineering costs in glass sector as well as the importance of satisfaction of the existing domestic demand to prevent penetration of other suppliers in to the country.

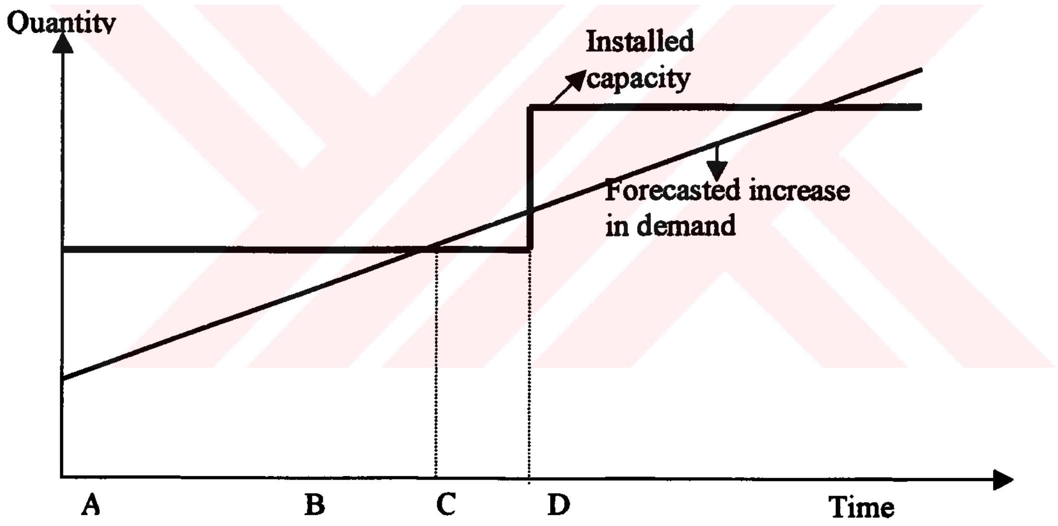


Figure 5-18 Typical investment point

The average cost function that Figure 5.18 calls to mind is cyclic as in Fig. 5.19, mainly due to costs of stock and productions over or under optimum scale. As demand in the market meets the supply, namely firm capacity, before new investment materializes, over scale production tendency increases the costs. New investment follows this and again causes the demand to fall short of capacity. As it was explained it is not possible to arrange the size of production elastically, so excess capacity causes excess stock costs, adding up to average costs of the firm.

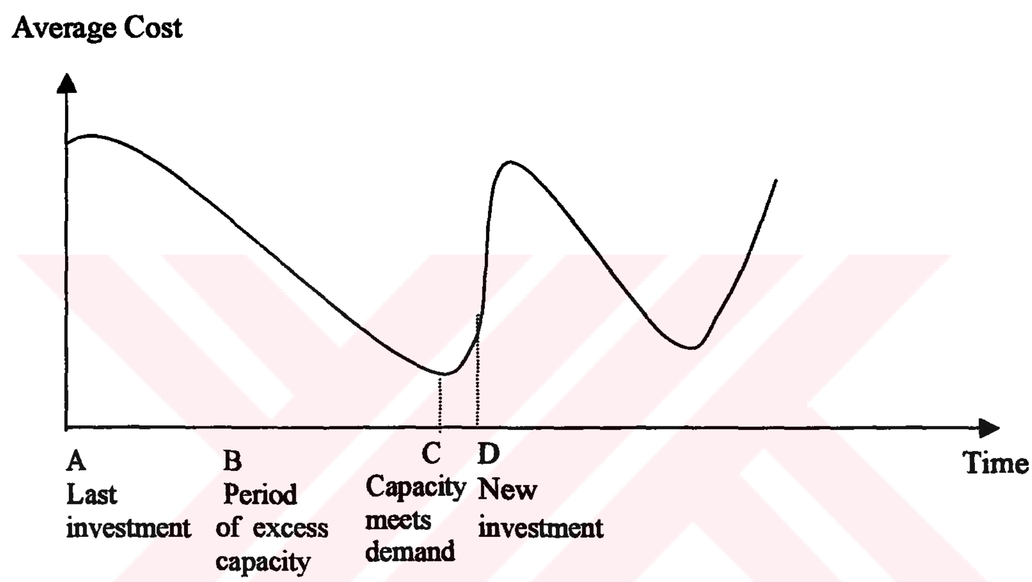


Figure 5-19 The Average cost function in relation to investment structure in Fig. 5.18

To make further analysis on this point, price is plotted with average variable cost data of Şişecam, in Fig. 5.20 with market index, to represent the situation in the market, which is defined as total sales to total production ratio of each year..

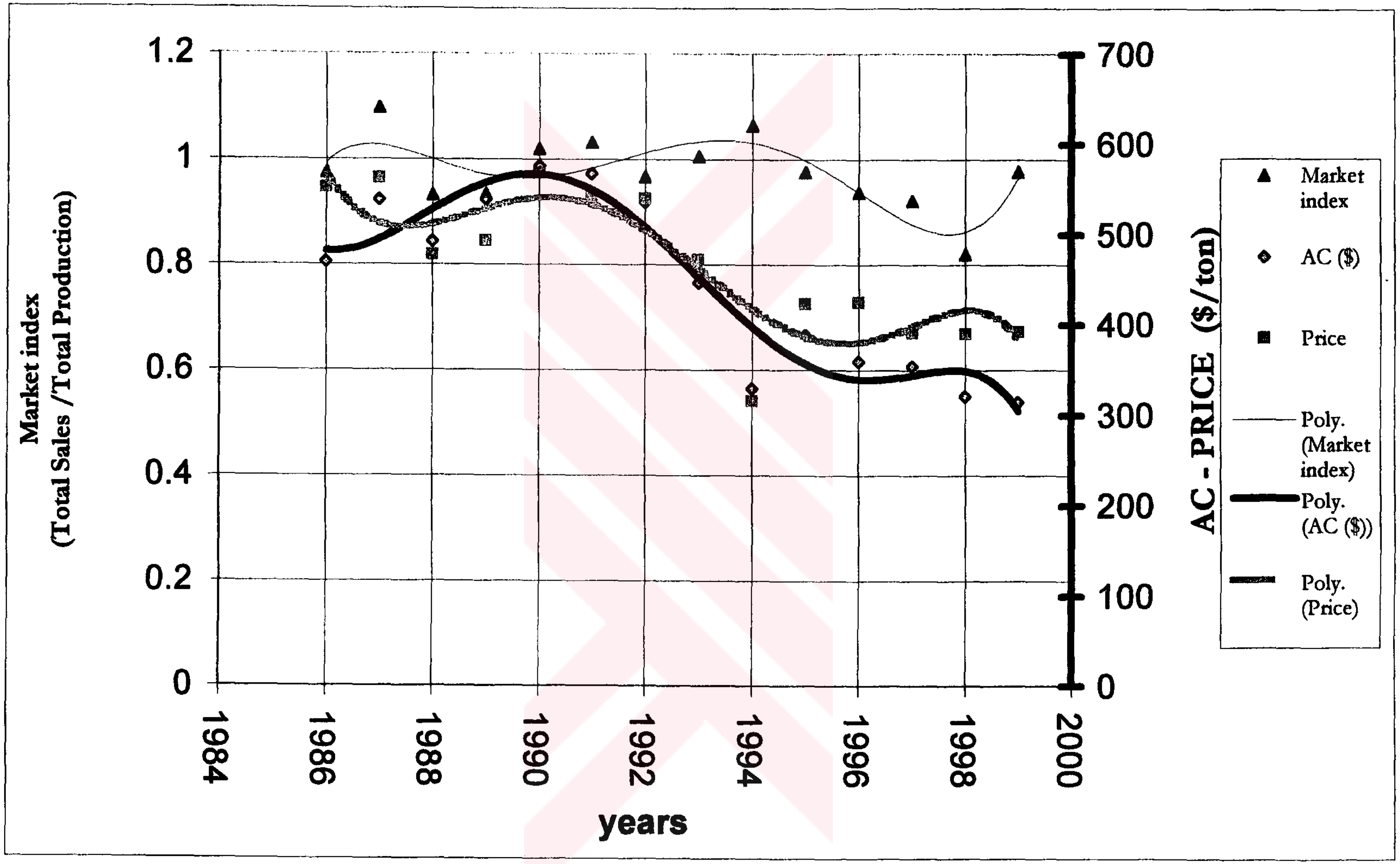


Figure 5-20 Price Average Cost (AC) and Total Sales

It can be deduced from Figure 5.20 that, the relative maximums of market index curve, coincides with relative minimums of average cost graph and vice versa. As referred before, the cost increase is due to producing below optimum level. When the market index takes the value 1, meaning total sales meets with amount of production, a critical point on average cost and price graph can be detected. Between 1987 and 1993, price remained short of average cost, while the market index value was less then one. After 1993, price exceeded average costs although kept its decreasing trend.

Marginal cost analysis would have given better analysis on price policy, however, as it is not meaningful to calculate marginal cost over consequent years by difference equation, where, different years can be characterized with different technology; and as it is not possible to derive the optimum cost function and marginal cost in consequence, the analysis could only be made on average costs.

Results seems supporting the ideas of Schumpeter. Even a dominant firm has incentive to engage in innovative activity. The firm in question, Şişecam's cost reducing R&D and new technology transfer activities has been referred above to be able to compete with substitutive competitors as well as the other giant suppliers in the world. In this manner it can be said that domestic R&D activities are seem to be more effective in cost reduction than technology transfer for the last years, although triggered by technology transfer, which coincides with the results of most of the similar studies carried out in the developing countries.

Data and regression results with statistical analysis (E-Views, GMM Method) are given here.

PRODUCTION AND COST DATA OF SISECAM - CONTAINER GLASS DIVISION

YEAR	$ - Purch. Power ind.	TOTAL SALES (tonnes)	PRODUCTION (tonnes)	Market Factor	RAW MATERIAL (tonnes)	ENERGY (sm3)	LABOR	CAPITAL ($)	R&D ($)	TECHNOLOGY TRANSFER ($)	ASSETS ($)	MACH&EQP ($)	TOTAL COST ($)	AVERAGE COST ($)
1999	1	412,158	421,813	0.977	569,735	89,015	1525	1,508,485	3,429,040	1,836,702	164,909,507	64,949,367	132,510,492	314
1998	1.02	437,161	532,872	0.820	592,027	72,868	2022	2,222,487	2,992,950	1,627,507	181,859,998	66,251,365	171,037,813	321
1997	1.04	364,517	395,321	0.922	465,836	59,428	1944	3,268,396	2,446,263	1,657,257	91,451,283	61,374,462	140,024,095	354
1996	1.06	308,859	329,491	0.937	290,826	48,169	1722	3,327,445	1,930,861	1,599,817	49,988,462	35,450,586	118,513,651	360
1995	1.09	300,857	308,390	0.976	314,688	40,242	1746	3,498,393	1,704,379	1,494,176	17,744,238	7,115,524	119,871,198	389
1994	1.12	317,742	298,601	1.064	312,428	30,480	1763	2,589,236	1,477,548	1,302,724	7,075,599	3,512,338	98,280,668	329
1993	1.15	305,604	303,882	1.006	371,166	72,347	1804	4,432,709	1,504,549	1,530,087	4,386,643	1,687,432	135,788,668	447
1992	1.19	283,894	293,644	0.967	387,911	76,781	1840	3,847,022	1,500,607	1,822,299	2,809,961	1,322,066	157,364,778	536
1991	1.22	260,704	252,676	1.032	365,623	64,281	1946	3,439,095	1,254,754	1,947,741	1,963,396	879,944	143,377,039	567
1990	1.27	270,850	265,780	1.019	362,665	75,997	1980	4,298,889	1,138,298	2,090,384	1,493,434	674,914	152,974,814	576
1989	1.34	238,205	254,971	0.934	323,613	53,373	2054	3,710,508	1,024,323	2,175,273	1,257,276	596,989	137,462,013	539
1988	1.41	210,800	226,072	0.932	238,888	31,707	2011	3,227,904	994,066	2,212,978	775,123	322,205	111,244,815	492
1987	1.47	199,201	181,512	1.097	150,325	33,466	1988	3,145,673	951,318	1,640,970	394,072	165,788	97,659,224	538
1986	1.52	195,251	200,277	0.975	212,365	46,658	1914	3,398,240	927,200	897,146	280,476	117,576	94,069,347	470

GMM // Dependent Variable is Q

Date: 10/12/00 Time: 10:06

Sample: 1986 1999

Included observations: 14

No prewhitening

Bandwidth: Fixed (2)

Kernel: Bartlett

Convergence achieved after 2 iterations

Instrument list: RM E L R T M

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RM	0.378532	0.033074	11.44488	0.0000
E	-0.074068	0.019160	-3.865851	0.0062
L	0.485802	0.185230	2.622688	0.0343
R	0.247699	0.070047	3.536177	0.0095
T	-0.076273	0.031950	-2.387287	0.0484
M	0.042360	0.011942	3.547037	0.0094
C	1.858704	1.862636	0.997889	0.3516

R-squared	0.977761	Mean dependent var	12.58685
Adjusted R-squared	0.958700	S.D. dependent var	0.289610
S.E. of regression	0.058856	Akaike info criterion	-5.358466
Sum squared resid	0.024248	Schwarz criterion	-5.038938
Durbin-Watson stat	2.833232	J-statistic	2.52E-21

Pairwise Granger Causality Tests

Date: 11/08/00 Time: 09:25

Sample: 1986 1999

Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
RM does not Granger Cause Q	13	0.47151	0.50790
Q does not Granger Cause RM		1.84069	0.20471
E does not Granger Cause Q	13	0.80914	0.38952
Q does not Granger Cause E		2.18488	0.17016
L does not Granger Cause Q	13	0.31578	0.58653
Q does not Granger Cause L		7.76737	0.01922
M does not Granger Cause Q	13	16.8529	0.00213
Q does not Granger Cause M		1.98919	0.18876
R does not Granger Cause Q	13	5.77630	0.03710
Q does not Granger Cause R		0.22356	0.64649
T does not Granger Cause Q	13	0.91308	0.36183
Q does not Granger Cause T		3.13140	0.10723

E does not Granger Cause RM	13	0.61043	0.45273
RM does not Granger Cause E		4.36498	0.06321
L does not Granger Cause RM	13	0.14777	0.70872
RM does not Granger Cause L		6.52255	0.02867
M does not Granger Cause RM	13	4.58837	0.05783
RM does not Granger Cause M		2.59079	0.13856
R does not Granger Cause RM	13	2.06416	0.18134
RM does not Granger Cause R		0.15598	0.70118
T does not Granger Cause RM	13	5.82426	0.03647
RM does not Granger Cause T		5.75847	0.03734
L does not Granger Cause E	13	1.14763	0.30922
E does not Granger Cause L		1.56638	0.23922
M does not Granger Cause E	13	2.05424	0.18230
E does not Granger Cause M		3.60706	0.08673
R does not Granger Cause E	13	1.26652	0.28671
E does not Granger Cause R		0.83165	0.38325
T does not Granger Cause E	13	4.65148	0.05642
E does not Granger Cause T		2.97203	0.11543

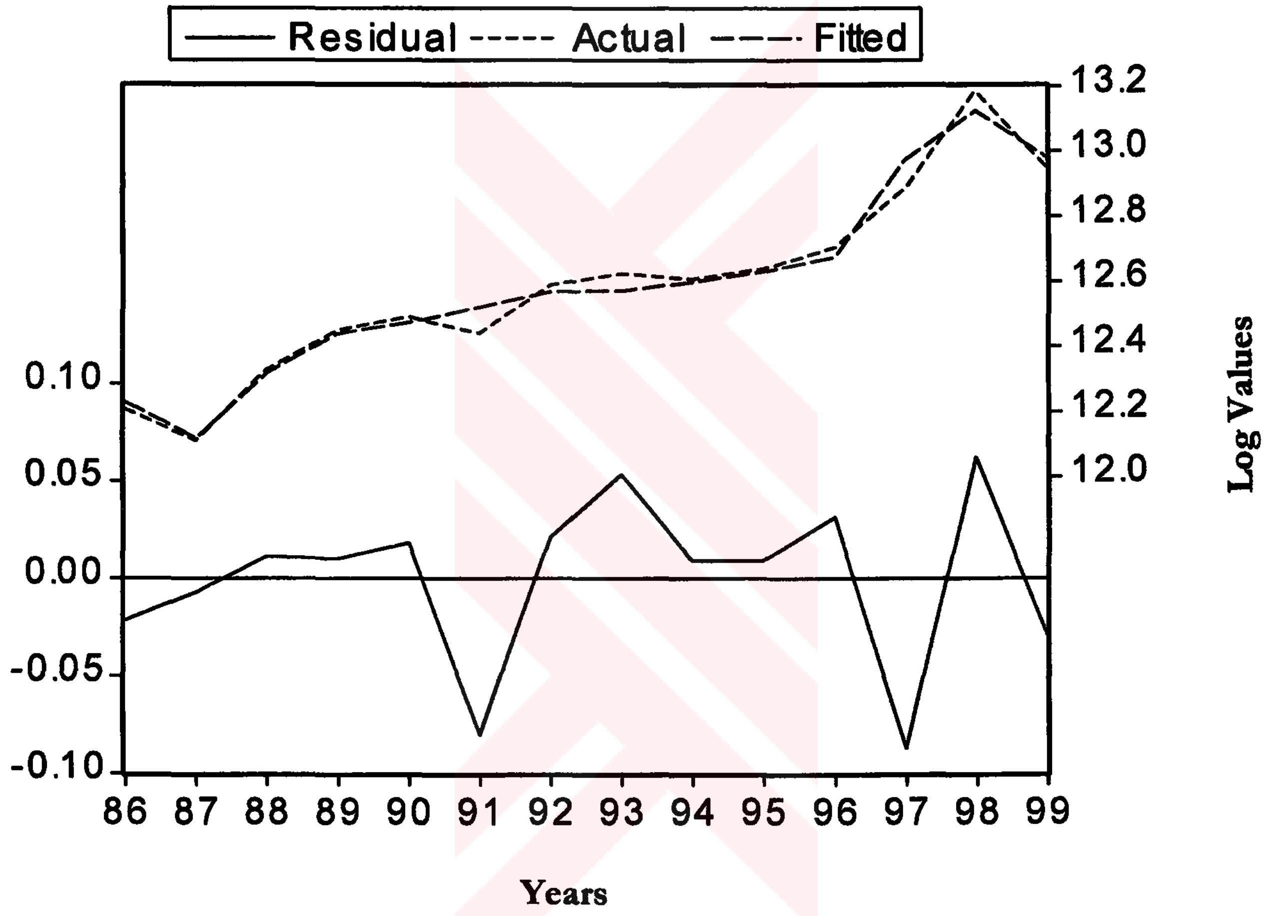
M does not Granger Cause L	13	2.40907	0.15168
L does not Granger Cause M		8.79668	0.01414
R does not Granger Cause L	13	5.33238	0.04357
L does not Granger Cause R		0.00806	0.93023
T does not Granger Cause L	13	0.02783	0.87084
L does not Granger Cause T		9.28056	0.01233
R does not Granger Cause M	13	0.41010	0.53632
M does not Granger Cause R		15.0573	0.00306
T does not Granger Cause M	13	0.42073	0.53119
M does not Granger Cause T		2.36092	0.15542
T does not Granger Cause R	13	0.19627	0.66718
R does not Granger Cause T		2.86577	0.12135

CORRELATION MATRIX

	Q	RM	E	L	M	R	T
Q	1	0.899791	0.5398	-0.363198	0.935217	0.946288	0.100957
RM	0.899791	1	0.758193	-0.294704	0.759024	0.814942	0.261091
E	0.5398	0.758193	1	-0.191514	0.381655	0.505603	0.251255
L	-0.363198	-0.294704	-0.191514	1	-0.497788	-0.552594	0.216911
M	0.935217	0.759024	0.381655	-0.497788	1	0.96099	0.059363
R	0.946288	0.814942	0.505603	-0.552594	0.96099	1	0.028838
T	0.100957	0.261091	0.251255	0.216911	0.059363	0.028838	1

COVARIANCE MATRIX

	Q	RM	E	L	M	R	T
Q	0.077883	0.088905	0.051956	-0.00808	0.566966	0.10795	0.006346
RM	0.088905	0.125349	0.092581	-0.008318	0.583768	0.117941	0.020822
E	0.051956	0.092581	0.11895	-0.005265	0.285941	0.07128	0.019519
L	-0.00808	-0.008318	-0.005265	0.006355	-0.086203	-0.018007	0.003895
M	0.566966	0.583768	0.285941	-0.086203	4.718961	0.853331	0.029047
R	0.10795	0.117941	0.07128	-0.018007	0.853331	0.16709	0.002655
T	0.006346	0.020822	0.019519	0.003895	0.029047	0.002655	0.050738



For "Q - Production" calculated by E-views

6 CONCLUSION

The results indicate that, the technology transfer has decreasing returns to scale with a negative power in the Cobb Douglas production function, formed with Şişecam's container glass division production and cost data between years 1986 and 1999. On the other hand domestic research activities' power in Cobb Douglas production function is positive representing increasing returns.

Actually, there has not been any significant technological development after NNPB, which is explained in Appendix 2, and which was transferred between years 1986 - 1987. The spending since then under the name of technology transfer consists of the annual fees paid to Heye Glas, the German glass producer supplying technical assistance to Şişecam during the analyzed years, for the audit type of services.[1] The improvement of this payment on productivity seems to be minor. NNPB on the other hand is a technology that helps to reduce the weight of each container keeping its resistance same. So a larger number of containers can be produced with the same tonnage of glass. However, production term is based on tons of glass, not the number of containers. Data on number of containers sold is available, not produced, and this figure is not meaningful to use in this analysis, as it is related to the conditions in the market environment, which are not modeled here. This fact may bring an error term with it.

However, technology transfer has been useful in triggering the adaptive research activities. Expenditures on research and development activities have increased

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[1] Besides the technical assistance agreement may be considered to be creating a media of sharing information and a base for trust.

considerably since 1986, whilst technology import payments decrease. This research has been on "applied" stage defined previously as concentrated on improvement of the existing technology. Although, a major technological innovation has not occurred within this time, it helped the firm to get an integrated understanding of the technology and develop its own, with minor adaptations.

With this perspective, Şişecam began to export its technology. Between years 1996 - 1999, technologic assistance was given to Middle East Glass, Egypt, and many projects, where Şişecam's role is considered to be technology supplier, are under investigation in CRS countries.

With the contribution of such innovative activities, Şişecam kept its position as a high market share supplier for world market and penetrated even to the territory of Saint Gobain, the second largest glass container manufacturer of the world, with high volume of sales.

The innovative activities helped Şişecam not to suffer more against PET's invasion to its market. Besides the effect of international competition in glass container market itself, the cutthroat competition of substitutive materials disturbed Şişecam's comfortable single supplier position to the market. This situation played a major role as a motive for its intensified innovative activity.

This point supports the thesis of Schumpeter, that, if necessary conditions of competitive threat is satisfied, namely if the market is contestable, the large firms with strong financial power are prone to the innovative activities. These large firms are likely to get better results than the firms active in highly competitive markets, as those firms are supposed to be small and as major research activities necessitate solid financial support.

Şişecam Group, besides its strong position in the market as single supplier for many years, it has İş Bank Group, one of the strongest financial organizations in the country, as the majority of shares holder, behind.

Therefore it has a solid financial power, however, the substitutive competitor PET has the world petrochemical industry behind, between the strongest industries in the world. Petrochemical industry's engagement in research and development activity is so intensive that it seizes all the strongholds of glass compared to PET, year by year. The efforts of glass industry do not prevent the victory of PET, but seems to reduce its acceleration.

PET's existence in the market prevented Şişecam to enjoy dominant position in terms of profits, being protected naturally with transportation barriers and the low labor costs in Turkey from international competition to some extent. Therefore prices remained even under costs for some years of excess supply in the cyclic nature of the business explained in the previous chapters. This competition can be referred as a regulator for a natural monopolist in this manner.

This regulating nature forced Şişecam to engage in cost reducing innovative activity, which is vital. Basic research on the other hand to improve the properties of glass as a packaging material against the substitutives is made by some research consortiums formed by a few container glass producers in the world. Şişecam also attends to these consortiums time to time.

After the regulations of GATT (World Trade Organization, with its current name) as the subsidies for international trade have been forbidden to governments, research and development subsidies has been popular. There is no comparison data for other companies and Turkey's research subsidy history is not that old to let a statistical analysis be made. Therefore, it is not possible to put a significant idea on the effect of government subsidies over the increasing research activities.

Container glass was the example industry in this study. In general, the economic situation's tolerance due to the low costs in the country (except energy) compared to the world let the industry to import the most recent technology up to now. However, as the economic conditions get harder such an opportunity may cease to exist. In addition, the Customs Union Agreement caused the profit margin of domestic suppliers to fall significantly. This fall may restrict the technology imports in the future and highlight the domestic R&D studies naturally.

APPENDİX I

World Glass Container Production

(Tonnes)	1997	2001
China	6,345,000	10,300,000
US	9,800,000	9,700,000
Germany	4,293,693	4,500,000
France	3,642,322	3,678,000
Italy	2,929,182	3,100,000
Mexico	2,105,100	2,440,000
UK	1,969,600	2,085,000
Japan	1,912,766	1,900,000
India	1,124,000	1,800,000
Spain	1,684,208	1,750,000
Thailand	1,250,000	1,625,000
B+DK+IRL+NL	1,447,710	1,560,000
Brazil	890,000	988,000
Poland	735,100	922,900
Portugal	751,221	860,000
Venezuela	790,000	850,500
Argentian	750,000	820,000
South Korea	785,000	800,000
Canada	710,000	780,000
Turkey	449,840	630,000
Colombia	410,000	550,000
Czech Republic	393,000	455,000
Austria	307,294	320,000
N+S+F	268,370	310,000
Hungary	270,000	307,000
Indonesia	200,000	280,000
Chile	193,073	257,000
Switzerland	166,177	168,000
Romania	160,000	193,000
Greece	92,500	93,700

(Tonnes)	1997	2001
Other Asia	1,051,000	1,260,000
South Africa	535,000	560,000
Other Countries	1600,000	1,750,000
Total	**50,012,056**	**57,138,555**

Source: **World Glass File 1999-2005, p:65**

B+DK+IRL+NL=Belgium, Denmark, Ireland, Netherlands
N+S+F=Norway, Sweden, Finland

APPENDIX II

TECHNOLOGIC IMPROVEMENTS

Glass container manufacturers have been unwilling to simply sit and monitor the advance of plastic technology, and have instead reacted by searching for greater innovation within their sector. With the increasing influence of the life style drink sector, product innovation in beverage containers has become especially important and glass container manufacturers have upped the pace of their product development in order to build brand image. However, the glass bottle is a relatively standard packaging medium and innovations have primarily revolved around subtle decoration techniques combined with the continuing program of lightweighting and efforts to increase shatter resistance. Differentiation has been achieved mainly through new bottle shapes, new labeling and sleeving techniques, embossing, screen printing on bottles and use of colored glass.

New age beverages have been the success story of the drinks industry in the last few years having grown from a very small base to a position where they command both a large slice of shelf space as well as premium prices. The high quality image these drinks aspire to has provided welcome relief for the glass packaging industry, which fits the requirements of this sector.

Glass bottles in this sector are usually distinctively shaped to ass shelf appeal to attract consumers towards relatively unfamiliar brand names. Wide mouth bottles have been used in flavored waters, while high-energy drinks commonly use shrink-sleeve labeling to enhance decoration.

Lightweighting

One of the principal reasons why the glass container has continued to be a viable packaging option for drinks producers is the development of lighter, stronger glass. Modern narrow neck press-blow (NNPB) technology for bottle production has been capable of reducing bottle weights by up to 20%. As well as substantially lowering freight costs, light bottles also satisfy environmental criteria by using fewer raw materials and generating less waste. Bottles produced with NNPB technology are also usually more visually attractive with less variance in the wall thickness of bottles.

The objective behind the development of NNPB, when applied to narrow neck bottles, is to improve glass distribution in the bottle and in so doing reduce the weight of glass while maintaining or even improving the mechanical performance of the bottle in respect of internal pressure resistance and impact resistance.

Technical improvements have also enabled the adaptation of lightweighting to returnable glass bottles. Ultra thin polymer coatings have been developed which gives bottles extra resistance to the increase handling, which comes with returnable bottles.

Most of the major glass container manufacturers have been actively researching and developing lightweight technology. In August 1999, Owens-Illinois launched a new process which substantially reduces the amount of glass needed to manufacture a typical glass bottle, making bottles 10%-20% lighter and their production faster and more cost effective. The company claims that its new line, Duraglas XL bottles retain all the functionality of current glass containers, including 100% recyclability, but with increased strength, reduced consumption of raw materials and energy, and lower transportation costs.

The process used in the production of Duraglas XL bottles embodies the company's proprietary cased gob technology. The bottles can be produced with less glass while fully meeting customer requirements for commercial performance.

Colored Glass

The use of colored glass is becoming increasingly popular among producers looking for shelf appeal. Blue has been common alternative to the standard green bottle, particularly for mineral and flavored water bottles.

Besides furnace technology, which allows producing large numbers of bottles economically with campaigns, out of furnace coloring technologies have been developed to allow a quick and elastic color transition. Coloring glass in forehearth by mixers for moderate number of demand is possible as well of adding color concentrates in a separate color cell fed from the forehearth.

APPENDIX III

TECHNOLOGY SPECIFICS OF GLASS CONTAINER SECTOR

Information used here are collected from the Technical Bulletins of Türkiye Şişe ve Cam Fabrikaları A.Ş. (Şişecam) – Basics of Glass Technology and Introduction to Glass Technology, 1993.

GLASS PRODUCTION

Glass, being in the form of solid physically, is an overcooled liquid, which is cooled down without having chance of crystallisation. It gains a non-flowing nature after cooled and gets a very hard nature. Although its tensile strength is very high when it is formed, it is quite sensitive to the environmental effects. Even a sensitive touch can create micro cracks in the surface, which reduces the strength considerably.

Raw materials of glass

Although every producer has its own batch formula, 90% of the glass is made of lime, soda and sand. Flat glass and container glass has 72% Si, 14% soda, 9% dolomite, lime, CaO+MgO, 4% Alumina, and 1% various oxides in its composition. Physical composition of raw material, like its grain size is as well important. Harmonisation of raw materials and the stability criteria to assure this harmonisation is absolutely required. Generally raw materials are produced domestically, in Turkey 98 % of the raw materials used are produced in Turkey.

Besides the above stated ones, some materials to speed the afination up are used like Sodium Sulfate, ammonium nitrate, ammonium chlorur, ammonium sulfate, and sodium chlorur. These are called secondary materials. Among this group, we can state some materials to quicken melting like sodium chlorur, B_2O_3, materials with florur and ammonium. By using these materials, same melting can be satisfied with a less furnace temperature. Colorogen materials are also among this group, like Au, Cu, Cd, Se, for red colour, MnO2, CeO2, Se^{-2} for pink, CdS for orange, UO_2, CeO_2, TiO_2 for yellow, Fe_2O_3, Cr_2O_3, CuO, U_2O_3 for green, CoO, FeO, CuO for blue, etc.

Another raw material of glass is cullet. Cullet reduces the melting temperature and gives the possibility of energy saving, at the same time adds to the quality.

Glass is a mixture of oxides. Each of these oxides affects the chemical and physical properties of glass in a different way.

Silicium di oxide, increases the viscosity of the melt glass, gives the glassy view to the glass and increases its resistance to thermal shocks and to acidic media. **Sodium oxide**, decreases the viscosity of the melt glass, increases heat expansion characteristic, thus reduces the resistance for thermal shock and decreases the melting temperature, water resistance and electrical resistance.

Calcium oxide, increases the water resistance of glass, improves the mechanical properties, but if excessive amount is used, gives rise to crystallisation.

Potassium oxide, has the similar effects to sodium oxide, but if it is used instead of sodium oxide, melting becomes difficult.

Lithium oxide, has similar effects to sodium oxide and potassium oxide.

Bor oxide, eases the melting process, but at the same time it is one of the glass making oxides. It decreases the melting temperature, heat expansion. A little amount of Bor oxide, improves the mechanical properties and causes a uniform glass distribution.

Alumina, eases melting if it is used with little amounts instead of CaO or SiO2, but if it is directly added to the batch, it has adversary effect, increases viscosity. It prevents crystallisation, and improves resistance of glass to thermic and mechanic shocks and to water.

Magnesium oxide, has effects similar to CaO, but is more effective on increasing viscosity, thus getting solidification faster.

Zinc oxide, having similar effects like MgO, is used mostly to obtain glass without bubble in purification of borosilicate glass and heat resistant glasses.

Lead oxide, decreases melting temperature of glass and viscosity, while increasing water resistance. It is used in getting glass, which can easily be operated and shaped.

Barium oxide, has effects similar to PbO and CaO. If it is used instead of CaO, the glass get can be melted much more easily.

Thus, according to the type of glass to be produced, the batch can contain oxides having effects in the direction of the purpose.

PRODUCTION PROCESS

Following the transportation of the raw materials to the factory, some materials are to be sieved and classified according to the grain sizes and stocked accordingly. From the stocks with batch conveyors, each product is fed to its silo with pneumatic systems. From these silos, materials are to be weighed according to the batch recipe and mixed, then fed to the glass melting furnace.

Glass melting furnaces are made of refractory materials with high heat resistance. There are mainly two types of glass furnaces: for flat glass and for container glass. Glass depth is generally between 1 - 1,5 m. Keeping depth smaller, can result in better flows in the furnace and better glass, but this time the temperature in the bottom of the furnace will be too high and finding proper material for such a furnace will be too costly. First part of the furnace is called melting zone. In glass furnaces there are a recuperator or a regenerator part, which are built to use the heat of the exhaust gasses. Furnaces can be fired with side burners or back burners, the flame between the glass surface and the crown, being around 1600 ^{0}C. The part from which the batch is fed is called doghouse. Generally, batch fed to furnace is around environment temperature, but before feeding batch in to the furnace preheating can be done, to increase its temperature, and to prevent a low temperature material to enter the furnace. At the surface, temperature is around 1500 ^{0}C and at the bottom, around 1200 ^{0}C. From the melting zone the glass flows to the working end, where there is a throat in container furnaces between these two zones, as it can be seen in Figure 1.

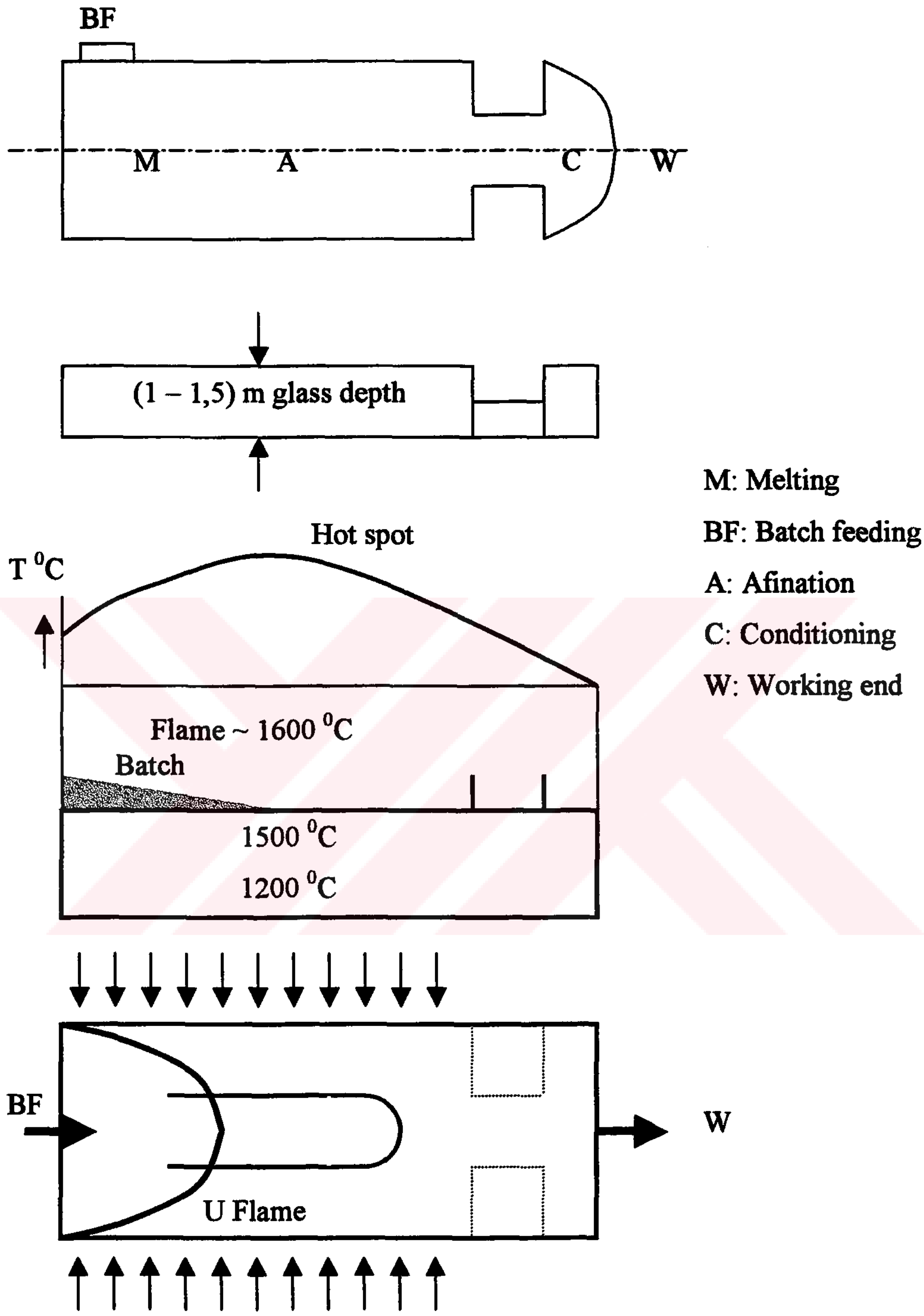

Figure App III-6 Container Glass Furnace

To make use of the heat of high temperature gases diffused from the fuel fired in the melting zone leaving the furnace, regenerator or recuperators are built in the furnace. Regenerators are built of refractory material having two parts, which work turn by turn by air and exhaust. Recuperators on the other side are built on the basis of heat exchanger.

There is an out of balance temperature distribution in the furnace stemming from the flame and batch. Due to these temperature variations, different regions have different densities and viscosities. Considering the temperature dependent heat expansion coefficient of glass, a glass column in 1500 ^{0}C part is higher than the one in 1100 ^{0}C, where this creates a natural flow from hot region to the cold. These currents are called belt currents and are around 5 to 10 times higher than the current generated due to pull of glass. Batch layer prevents radiation heat transfer from the flame to the glass and causes the glass at the bottom to be comparatively colder. Having high density, the glass in this region flows through the hot region.

These flows are affected both from temperature variations, and size of the furnace. As the width of the furnace gets larger, because the friction per volume of glass will be lower and the pressure difference will be higher, total flow will be more. On the other side, if the furnace gets longer or, narrower, friction per volume of glass will be higher and pressure difference will be lower; thus total flow will be less.

In afination section the seeds in the glass are removed, and then it is conditioned to the working temperature around **1200 ^{0}C** in the working end. At the end of the working end glass passes from forehearths, which are conditioning channels, and comes to feeder to be fed in to the machine. Glass is fed from an orifice at the centre of a schamot pot placed at the end of the forehearth by the push of plunger with definite strokes. Shears cut the gob at the desired shape and weigh, and the gob flows through the gob deflectors in to the moulds of the IS machines (Individual Section machine).

IS machine is composed of individual sections assembled next to each other and connected with a drive shaft. Timing of the machine is either made with a time lute or electronically. There are two stages of production and two methods. According to type of product either "blow-blow" or "press-blow" method is used. Gob firstly comes to first old and parison is formed at this stage, and then transformed to finisher to take its final shape. From this step, articles go in to the annealing lehr to be heated to 650 ^{0}C and then cooled down with a controlled regime. This process relieves the residual stresses from the bottle, and improves mechanical strength. As the bottle comes out of annealing lehr, cold coating is applied to the bottle, to fill the micro-cracks. Bottles further move on to the inspection machines, for the detection of defects. After this stage, bottles are packed and transmitted to the storing units.

PHYSICAL AND CHEMICAL PROPERTIES OF GLASS

Physical and Chemical properties of glass are determined by the glass composition and production process. Although density of glass varies between 2,2 - 7,2 gr/cm^3 depending on the type of the glass, flat glass and container glass have a density between 2,3 and 2,6 gr/cm3.

Heat expansion characteristic is important in determining the resistance of glass to temperature shocks. The coefficient of heat expansion for glass is generally in the limits of 5,6 x 10-7 and 140 x 10-7 cm/(cm x 0C). Glass can generally resist to shocks within the limit of 100-350 0C. Heat expansion coefficient, mechanical resistance, heat diffusion in the glass and dimensions have major roles in the formation of the due stresses.

One of the most important points in shaping the glass is the characteristics of temperature-glass viscosity curve, and value of viscosity at some definite temperatures. Chemical resistance of glass decreases with the increase in the amount of alkali in the glass.

Heat conductivity of glass is 0,0028-0,0078 Cal/cm x 0C, but it can be increased with soda, potassium, and lead oxide mixtures. Heat capacity of glass increases with the temperature of the glass.

Measurable mechanical strength of glass is determined as 2,7 x 105 kg/cm2. It is almost completely elastic at room temperature. The Poisson ratio is between 0,15 and 0,26. The hardest glasses are Borosilicate glasses and the lead containing ones are the reverse; but all types of glasses have Hardness number (Mohr) between 5 (Apatite) and 7 (Quartz). For new or chemically cleaned glasses, static friction coefficient is low, but it can further decrease to 0,16 - 0,242 by contacting with air for a long time and with other contamination.

Glass is generally known as a high resistant material for electricity. Dielectric coefficient of glass depends on composition of the glass, temperature and frequency; but within the limits of 3,7 and 16,5.

Refraction index of glass is between 1,45-1,90. For the silicate glass typical reflection is 4%, but a completely transparent glass reflects 92% of the light. Heat conductivity of glass decreases with reflection and absorption properties and varies with wavelengths considerably. As different colors affect the transmissibility of light, chemical composition of glass is also effective especially for the lights with short wavelength. Stress-optic coefficient and photo-chromism are two more important properties of glass. Stress-optic coefficient is effective for the glass, which has anisotropic stresses and strains, and transmissibility characteristics change according to the direction of the light. Photo-chromism, on the other side measures the change in light transmissibility of glass with light. (Technical Bulletin – Şişecam - Basics of Glass Technology)

REFERENCES

ADAMS F. G., 1985, Industrial Policies for Growth and Competitiveness: Volume II Empirical Studies, D.C. Heath and Company

AIGINGER K., PFAFFERMAYR M., 1997, " Looking at the Cost Side of Monopoly", The Journal of Industrial Economics, pp: 245-267

ALAVI R., 1999, "Technology Transfer and Patents: The Impact of Trips on Muslim Countries", Journal of Economic Cooperation, Volume: 20, p:21-38

ANNUAL REPORT's of Türkiye Şişe ve Cam Fabrikaları A.Ş., (Between years 1986 – 1999)

BASANT R., FIKKERT B., 1996, "The Effects of R&D, Foreign Technology Purchase and Domestic Spillovers on Productivity in Indian Firms", The Review of Economics and Statistics, pp: 187-199

BASANT R., 1993, "R&D, Foreign Technology Purchase and Technology Spillovers in Indian Industry: Some Explorations", Working Paper No: 8, United Nations University, Institute of New Technologies, Maastricht

BAUMOL, W. J., BRAUNSTEIN Y.M.,1977, "Empirical Study of Scale Economies and Production Complementarity: The Case of Journal Publication", Journal of Political Economy, V:85, No:5, pp: 1037-1048

BAUMOL, W. J.,1982, "Contestable Markets: An Uprising in the Theory of Industry Structure", American Economic Review, Vol.:72, No:1, pp:1-15

BELL M., PAVITT K., 1997, "Technological Accumulation and Industrial Growth: Contrasts Between Developed and Developing Countries", in Daniele Archibugi, Jonathan Michie, eds., "Technology

Globalisation and Economic Performance", p: 83-137, Cambridge University Press.

BLOMSTRÖM M., 1986, "Foreign Investment and Productive Efficiency: the Case of Mexico", The Journal of Industrial Economics, pp: 97-110

BRAGA H., WILLMORE L., 1991, "Technological Imports and Technological Effort: An Analysis of Their Determinants in Brazilian Firms", The Journal of Industrial Economics, pp: 421-432

BRANDER J.A., SPENCER, B. J., 1983, "Strategic commitment with R&D: The Symmetric Case.", Bell Journal of Economics, 14 (1), pp: 225-35

BREMS H., 1968, "Quantitative Economic Theory: A Synthetic Approach", JohnWiley & Sons Inc., NewYork

CHOI J.P., 1993, "Cooperative R&D with Product Market Competition", International Journal of Industrial Organization, 11, pp:553-571, North Holland

COMBS K.L., 1993, "The Role of Information Sharing in Cooperative Research and Development", International Journal of Industrial Organization, 11, pp:535-551, North Holland

CREPON B., DUGUET E., MAIRESSE J., 1998, Research, Innovation, and Productivity: An Econometric Analysis at the Firm Level, NBER Working Paper Series, Working Paper. 6696

CULBERTSON J.D., 1985, "Econometric Tests of the Market Structural Determinants of R&D Investment: Consistency of Absolute and Relative Firm Size Models", The Journal of Industrial Economics, pp:101-108

DAHLMAN C.J., LARSON B.R., WESTPHAL L.E., 1987, "Managing Technological Development: Lessons from the Newly Industrialising Countries", World Development, Vol.:6, pp: 759-775, Pergamon Journals Ltd.

D'ASPREMONT, CLAUDE, JACQUEMIN A., 1988, "Cooperative and non-cooperative R&D in Duopoly with Spillovers", The American

Economic Review, Vol:78, pp: 1133-1137

DAUGHETY A. F., 1985, "Reconsidering Cournot: The Cournot Equilibrium is Consistent", Rand Journal of Economics, Vol.:16, No:3, pp: 368-379

DAUGHETY A.F., 1988, "Introduction, Purpose and Overview" in Andrew Daughety, ed., Cournot Oligopoly: Characterizations and Applications, pp: 3-44, Cambridge: Cambridge University Press

DE LONG J.B., 1988, "Productivity, Growth, Convergence, and Welfare: Comment", The American Economic Review, Vol:78 pp: 1138-1154

DEMSETZ H., 1969, "Information and Efficiency: Another Viewpoint", Journal of Law and Economics, Vol.:12 No:1, pp:1-22

DEMSETZ H., 1974, "Two Systems of Belief About Monopoly", in Harvey J. Goldschmid, Michael H. Mann, and J. Fred Weston, eds., Industrial Concentration: The New Learning, pp:164-184, Boston: Little, Brown

DEOLALIKAR A.B., EVENSON R., 1989, "Technology Production and Technology Purchase in Indian Industry: An Econometris Analysis", The Review of Economics and Statistics, pp:687-692

DIXON H., 1996, "The Cournot and Bertrand Outcomes as equilibria in Strategic Metagame", Economic Journacl, Vol.:96, Supplement, 1986, pp: 59-70

FERGUSON C.E., 1966, Microeconomic Theory, Richard D. Irwin Inc.

FERRANTINO M. J., 1992, "Technology Expenditures, Factor Intensity, and Efficiency in Indian Manufacturing", The Review of Economics and Statistics, pp: 689-700

FISHER I., 1898, "Cournot and Mathemetical Economies", Quarterly Journal of Economics, Vol.:12, No:2, pp: 119-38 in Andrew Daughety, ed., Cournot Oligopoly: Characterizations and Applications, pp: 3-44, Cambridge: Cambridge University Press

FORS G., 1997, "Utilizaion of R&D Results in the Home and Foreign Plants of Multinationals", The Journal of Industrial Economics, pp: 341-358

FRIEDMAN L. S., 1984, Microeconomic Policy Analysis, Mc.Graw-Hill Inc.

GUJARATI D., 1978, Basic Econometrics, McGraw-Hill Book Company Inc.

HAY D.A., MORRIS D., 1979, Industrial Economics Theory & Evidence, Oxford University press

İNCESU Y., 1996, Cam Sektörü Raporu, T.C. Başbakanlık Dış Ticaret Müsteşarlığı Orta Anadolu İhracatçı Birlikleri Genel Sekreterliği

IWATA, G., 1974, "Measurement of Conjectural Variations in Oligopoly", Econometrica, Vol: 42, No: 5, pp: 947-966

JACQUEMIN A., 1987, "Collusive Behavior, R&D and European Policy", Economic Papers No: 61

JOHNSON L., 1968, "Production Functions and the Concept of Capacity", Sur La Fonction De Production, Recherches Recentes, Centre D'etudes et de Recherches Universitaire De Mamur Facilte: Universitaires N-D, de La Paix

JOHNSTON J., 1960, Statistical Cost Analysis, McGraw-Hill Book Company Inc.

JOVANOVIC B., NYARKO Y., 1995, "Research and Productivity", NBER Working Paper Series, Working Paper: 5321

KAMIEN M.I., SCHWARTZ N.L., 1974, "On the Degree of Rivalry for Maximum Innovative Activity", Discussion Paper No: 64, Center for Mathemetical Studies in Economics and Management Science.

KAMIEN M.I., SCHWARTZ N.L., 1975, "Market Structure and Innovation: A Survey", Journal of Economic Literature 13, pp:1-37

KATRAK H., 1985, "Imported Technology, Enterprise Size and R&D in a Newly Industrializing Country: The Indian Experience", Oxford Bulletin of Economics and Statistics 47, 213-229

KATRAK H., 1989, "Imported Technologies and R&D in a Newly Industrialising Country: The experience of Indian Enterprises", Journal of

Development Economics 31, pp:123-139, North Holland.

KLEINKNECHT A. 1987, "Measuring R&D in Small Firms: How Much Are We Missing?", The Journal of Industrial Economics, pp.253-256

KUMAR N., 1998, "Technology Generation and Transfers in the World Economy: Recent Trends and Prospects for Developing Countries" in Globalization, Foreign Direct Investment and Technology Transfers, Routledge, p: 11-42

LESOURNE J., 1976, "The Optimal Growth of the Firm in a Growing Environment", Journal of Econometric Theory 13, pp:118-137

LICHTENBERG F.R., 1987, "The Effect of Government Funding on Private Industrial Research and Development: A Reassessment", The Journal of Industrial Economics, pp:97-104

MAIRESSE J., DUGUET E., CREPON B., 1998, "Research, Innovation and Productivity: An Econometric Analysis at the Firm Level",National Bureau of Economic Research, Working Paper 6696

MAIRESSE J., HALL B.H., 1996, Estimating the Productivity of Research and Development: An Exploration of GMM Methods Using Data on French and United States Manufacturing Firms, NBER Working Paper Series, Working Paper 5501

MANSFIELD E., 1997, Applied Microeconomics, W.W. Norton & Company, Inc., 2nd Ed.

MARTIN S.,1993, Advanced Industrial Economics, Blackwell Publishers Inc.

MARTIN S.,1994, Industrial Economics, 2nd ed., Prentice Hall Inc.

MUELBAUER J., "The Assessment Productivity and Competitiveness in British Manufacturing", Oxford Review of Economic policy, Vol.:2 No:3

NAYLOR T. H., VERNON J. M., 1969, Microeconomics and Decision Models of the Firm, Harcourt Brace & World Inc.

NELSON R.R., Peck M. J., KALACHEK E. D., 1967, The Brookings Institution Washington D.C.

NELSON R.R., WINTER S.G., 1977, "Simulation of Schumeterian Competition", American Economic Association (Papers and proceedings), V:67 No:1

NELSON R.R., WINTER S.G., 1977, "Dynamic Competition and Technical Progress", in Bela Balassa, Richard Nelson (eds.), Economic Progress, Private Values and Public Policy. Essays in Honor of William Fellner, , North Holland, Amsterdam

NORDHAUS W., 1969, "Invention Growth and Welfare: A Theoretical Treatment of Technological Change", Cambridge, Mass.:MIT Press.

OZAWA T., 1985, "Macroeconomic Factors Affecting Japan's Technology Inflows and Outflows: The Postwar Experience" in Rosenberg N. and Frischtak C. (eds.), International Technology Transfer (Praeger, NewYork), pp:222-254.

ROSENBERG J.B., 1976, "Research and Market Share: A Reappraisal of the Schumpeter Hypothesis", The Journal of Industrial Economics, pp:101-112

SCHERER F.M., 1967, "Research and Development Resource Allocation Under Rivalry", Quarterly Journal of Economics, No:3

SCHERER F.M., 1972, "Nordhaus Theory of Optimal Patent Life: A Geometric Reinterpretation", American Economic Review 62, pp: 422-427

SCHUMPETER J.A., 1975, "Capitalism, Socialism, and Democracy", NewYork: Harper & Row, Colophon ed.

SHEPHARD W.G., 1990, "The Economics of Industrial Organization", 3rd ed., Prentice-Hall, International Editions.

SHY O., 1995, Industrial Organization Theory and Applications, The MIT Press

SIMPSON R.D. VONORTAS N.S., 1994 March, " Cournot Equilibeium with Imperfectly Appropriable R&D", Journal of Industrial Economics, p:79-92

SMITH A., 1937, "An Inquiry in to the Nature and Causes of the Wealth of Nations", Edwin Cannan, ed., NewYork: The :modern Library.

SWAN P.L., 1970, "Market Structure and Technological Progress: The Influence of

Monopoly and Product Innovation", Quarterly Journal of Economics, pp:627-638

ŞİŞECAM, 1993, "Introduction to Glass Technology", Dept. of Training

TECHNICAL BULLETINs of Türkiye Şişe ve Cam Fabrikaları A.Ş.

TEITEL S., 1984, "Technology Creation in Semi-Industrial Economies", Journal of Development Economics, pp: 39-61

TIROLE J., 1995, The Theory of Industrial Organization, Eight printing, The MIT Press

VII. Beş Yıllık Kalkınma Planı Sanayileşme Politikaları Özel İhtisas Komisyonu, "Sanayide AR-GE Faaliyetleri Firma İlişkileri ve Teknolojinin Geliştirilmesine Yönelik Politikalar Alt Komisyon Raporu"

WALDMEN D. Jensen E., 1998, Industrial Organization Theory and Practice, Addison-Wesley Educational Publishers Inc.