A game theoretic analysis of South Africa's cellular information and communication technology sector

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Thesis submitted in the School for Economics, Money and Banking of the Potchefstroomse University for Christen Higher Education in partial fulfilment of the requirements for the degree Magister Commercii (Economics)

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POTCHEFSTROOM

April, 2001

Acknowledgements

First and foremost, I would like to thank my Lord and Saviour Jesus Christ, for giving me the ability to study. May we glorify Him in everything we do.

I would like to thank all the people who contributed to this dissertation. The following persons, however, deserve special mention and are acknowledged for their willing cooperation and assistance.

To Professor Wim Naude, in his capacity as supervisor of this dissertation, my sincere appreciation for his guidance, constructive advice and support. Despite his busy schedule, he was always willing to advise and assist me on a wide variety of issues.

To the personnel of the Ferdinand Postma library, especially Mrs. E. Roodt, for assisting me in locating material and for checking my references.

To Karina Lemmer for editing my dissertation.

To my parents for their continuous faith in me.

A special note of thanks to my wife, Juanita, whose love and support carried me.

"Everyone takes the limits of his own vision for the limits of the world" –
Arthur Schopenhauer

Abstract

A game theoretic approach of South Africa's cellular information and communication sector

The "new economy" has become a reality for South Africa. An economy driven by factors such as globalisation and technology. If South Africa wish to partake in the benefits of globalisation the promotion of cellular information and communication technology (ICT) may be a vital part of any economic development strategy. This is because the internalisation of services is at the core of economic globalisation. Service industries such as communication and transport technologies provide links between geographically dispersed economic activities and thus play a fundamental role in the growing interdependence of markets and production activities across nations.

The deregulation of South Africa's cellular ICT sector has lead to the licensing of a third network operator. A game theoretic approach was used to determine what effect the entrance of a third cellular network provider will have on the South African cellular information, communication and technology (ICT) sector and the sector's contribution to economic development.

The problem managers of firms (in monopolistic market structures) have is how to use their market power most effectively. They must decide how to set prices, choose quantities of factor inputs, and determine output in both the short and long run to maximise the firm's profit. Managers of firms with market power have a harder job than those who manage perfectly competitive firms. Managers of firms with monopolistic power must also obtain information about the characteristics of demand. Even if they set a single price for the firm's output, they must obtain at least a rough estimate of the elasticity of demand to determine what that price (and corresponding output level) should be.

This study determines that the traditional way of modelling oligopolistic behaviours does not adequately capture the multitude of dynamic interactions

which could arise in an oligopolistic market setting and that one approach to this problem involves the use of game theory, which has the added virtue of reinforcing our understanding of oligopolistic interdependence.

Opsomming

‘n Spelteoretiese analise van Suid Afrika se sellulêre inligting en kommunikasie tegnologie sektor

Die nuwe ekonomie het ‘n realiteit geword vir Suid Afrika. ‘n Ekonomie wat gedryf word deur globalisering en tegnologie. Indien Suid Afrika voordeel sou wou trek uit hierdie globalisering is ‘n ontwikkelingstrategie nodig, wat klem plaas op die uitbouing van die inligting en kommunikasie tegnologie (IKT) sektor. Die rede hiervoor is dat die internasionalisering van dienste die dryfveer van ekonomiese globalisering is. Diens sektore, soos kommunikasie en vervoer tegnologie, verskaf verbindings tussen geografiese verspreide ekonomiese aktiviteite en vorm dus ‘n grondslag vir die groeiende interafhanklikhede van markte en produksie aktiviteite internasionaal.

Die de-regulering van Suid-Afrika se sellulêre IKT sektor het gelei tot die lisensiering van ‘n derde netwerk operateur. Hierdie studie maak gebruik van spelteorie om te bepaal wat die effek van die toetrede, van die nuwe operateur op Suid-Afrika se sellulêre IKT sektor gaan wees en die sektor se bydra tot ekonomiese ontwikkeling.

Die vraagstuk van meeste bestuurders (van ondernemings met markkragte) is hoe om hulle markkrag effektief te gebruik Hulle moet besluit oor pryse, inset - en uitset hoeveelhede om maksimum winsgewendheid oor die kort- en langtermyn te verseker. Die taak om ondernemings met markkragte te bestuur is egter meer gekompliseerd as ondernemings in volledige mededingende markte. Bestuurders van ondernemings met monopolistiese kragte, moet ook inligting bekom oor kenmerkende eienskappe van die markvraag. Selfs as hulle van ‘n vasgestelde uitset prys gebruik maak, moet hulle ten minste ‘n ruwe benadering van die elastisiteit van die vraag hê, om te bepaal wat die prys (en ooreenstemmende uitset vlak) moet wees.

Hierdie studie bepaal dat die tradisionele manier van oligopolistiese gedrags modellering nie die menigte van dinamiese interaksies voldoende kan

weergee nie. Spelteorie bied ‘n doeltreffende toegangsweg tot hierdie probleem, om ons begrip oor oligopolistiese afhanklikhede te versterk.

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Chapter 1: Introduction

1.1 Introduction

The objective of this study is to determine what effect the entrance of a third cellular network provider will have on the South African cellular information, communication and technology (ICT) sector and the sector's contribution to economic development. The present chapter is an introduction on why and how this study will be conducted. The chapter is structured as follows; In section 1.2 the hypothesis of the study is given. In section 1.3 the problem statement is given followed by the methology in section 1.4. In section 1.5 definitions and concepts used through the study is given. In section 1.6 the layout of the study is given. In section 1.7 a summary of this chapter is given.

1.2 Hypothesis

The entrance of a third cellular telephone network provider in South Africa in 2000 or 2001 will have a positive effect on the South African cellular ICT sector and the sector's contribution to economic development.

1.3 Problem statement

1.3.1 Cellular information and communication sector

The cellular ICT can make a valuable contribution to the economic development of countries and regions. The internationalisation of services is at the very core of economic globalisation. Service industries provide links between geographically dispersed economic activities and thus play a fundamental role in the growing interdependence of markets and production activities across nations (Archibugi & Michie, 1997:4).

If South Africa, and indeed Africa, wish to partake in the benefits of globalisation, promotion of the cellular ICT may be a vital part of any economic development strategy. Africa comprises 20 percent of the world's landmass and contains 12 percent of its population. But it accounts for only 2 percent of the world's telecommunications (Noam, 1999:3). It is in the wireless communication industry especially where Africa, including South Africa, could benefit from recent technological advances. According to Zysman et al. (2000:107) the wireless communication industry is undergoing a revolution. Within the next two years, the number of worldwide mobile and personal communications subscribers is expected to exceed half a billion. Within the next five years, the number of wireless subscribers is expected to surpass the number of worldwide wireline subscribers. If Africa is to start "bridging the digital divide" it should consider strategies to increase the access of its populations to wireless communication services.

Mobile cellular communications was launched in South Africa in 1994, with Vodacom and MTN as the two network operators. This sector has had an annual growth rate of 50 percent. As a result of this rapid growth South Africa is the largest Global System for Mobile Communications (GSM) technology network outside of Europe and is the fourth fastest growing GSM market in the world (Hodge, 1999a:17).

1.3.2 Game theory

MTN and Vodacom (duopology) are now facing the entrance of the new cellular network provider , possibly in late 2001 or 2002. Whereas the current market structure is one of duopoly, the future structure will be oligopolistic. In such a structure, the pricing and marketing behaviour of firms will be different, and the welfare implications may also be different (Antinou, 1993:285).

The role of the government should be to create a regulatory environment that facilitates the rapid growth of all networks (Hodge & Miller, 1997:4). In November 1999 one more license was awarded by the South African Telecommunications Regulatory Authority (SATRA) (Hodge, 1999a:24).

It may be argued that the deregulation of South Africa's cellular sector may be welfare-improving, if it leads to improved communication links and decreases costs. As the price-quality mix of producers services (i.e., services that are inputs into the production of other goods and services) improve this has a positive feedback effect in terms of the demand for services. It allows firms to specialise in their core competencies and outsource needed inputs, benefiting from improved communication and coordination links (Hoekman & Primo Braga, 1997:4). In this study game theory will be used to investigate whether the outcome of the deregulation of the cellular ICT industry in South Africa may be welfare-improving. Game theory will suggest an optimal solution in the face of an opponent who has a strategy of its own.

1.4 Methodology

This study will utilise a literature study and mathematical modelling, using game theoretic concepts.

Chapter two consists of a literature overview of South Africa's cellular ICT industry and the role this industry plays in a country's economic development.

In chapter three imperfect competition models are examined through a literature study of duopolictic and oligopolistic models. Firstly, the non-cooperative oligopolistic models of Cournot and Stakelberg will be examined. Cooperative oligopolistic market structures will be examined using cartelism. The economic welfare implications of these market structures are then examined.

In chapter four a literature study is used to describe and evaluate techniques used in game theoretical modelling. Game theory is an abstract framework for analysing strategic behaviour and has become an important tool in economic theory during the last fifty years. Game theory is used extensively by industrial organisations but is also used in many other fields of economic theory such as: labour market economics, political economics, environmental economics, and general macro-economics, to model behaviour both in markets (imperfect competition, auctions, bilateral bargaining) and outside markets (policy coordination among different countries or groups, regulation, corruption, policy, choice, contracting) (Sloth, 2000).

Game theory is a branch of mathematical analysis developed to study decision making in conflict situations. Such a situation exists when two or more decision-makers, who have different objectives, act on the same system or share the same resources (Heylichen et al, 2000). Game theory provides a mathematical process for selecting an optimum strategy (an optimum decision or a sequence of decisions) in the face of an opponent who has a strategy of its own (Mcafee et al, 1996).

In chapter five a mathematical model of South Africa's cellular ICT sector is presented using these game theoretic concepts. The model is used to determine the effect of the entrance of a third cellular network provider on the South African ICT sector. Chapter six concludes.

1.5 Definitions and concepts

Game theory	Game theory is concerned with the actions of individuals who are conscious that their actions affect each other (Rasmusen,1992:21).
Finite games	Games in which each player has only a finite number of possible actions available to him (Basar & Olsder, 1982:10).
Infinite games	In these games the players know exactly (during each period) to which point the game has evolved and that information is fed back into their strategies, which then leads to certain actions (Basar & Olsder, 1982:10).
Cooperative game	A cooperative game is a game in which the players can make binding commitments (Rasmusen, 1982:29).
Non-cooperative	In non-cooperative games the players cannot make binding agreements. This theory is economic in favour;

	with solution concepts based on players maximising their own utility function (Rasmusen, 1982:29).
Nash equilibrium	This is an equilibrium point between players, where one player cannot improve his outcome by altering his decision unilaterally (Basar & Olsder, 1982:5).

1.6 Layout

Chapter two provides an overview of South Africa's cellular ICT sector. Firstly, the cellular ICT's contribution to the South African economy is given. Secondly, the different types of network providers are identified and discussed. Then, the cellular ICT sector, the nature of production and forms of trade are discussed. Finally, the regulations governing competition and trade in the telecommunications sector are identified.

In chapter three duopoly, oligopoly and welfare economics are set out. Firstly, the chapter outlines the structure of the cellular ICT sector in South Africa. Thereafter the theories of oligopolistic market structures are discussed. Finally the economic welfare implications of this sector on a country's economy are derived.

Chapter four examines the use of game theory to model oligopolistic behaviour. This chapter starts off by giving a description of game theory. Thereafter game theoretic concepts are examined, initially through zero-sum games and thereafter non-zero sum games are examined by the introduction of the Nash – and Stackelberg equilibrium solution concepts.

In chapter five, game theoretic modelling will be used to determine the impact of a new entrant into South Africa's cellular ICT sector.

Chapter six concludes.

1.7 Summary

In this chapter the objectives of this study was set out. In section 1.2 the hypothesis of the study was given. In section 1.3 the study's problem statement was defined. In section 1.4 the metrology was described. In section 1.5 the main concepts to be used were defined. Section 1.6 presented the structure of the study. In the next chapter, South Africa's ICT sector will be examined.

Chapter 2: The South African Cellular ICT sector

2.1 Introduction

It was stated in chapter one that if South Africa wish to partake in the benefits of globalisation, promotion of the cellular ICT may be a vital part of any economic development strategy. This is because the internalisation of services is at the core of economic globalisation. Service industries such as communication and transport technologies provide links between geographically dispersed economic activities and thus play a fundamental role in the growing interdependence of markets and production activities across nations (Archibugi & Michie, 1997:4).

Chapter one also identified the cellular ICT industry in particular as a sector where South Africa could benefit from recent technological advances. However, for South Africa to "bridge the digital divide" it should consider strategies to increase the access of its population to cellular ICT services (Zysman et al, 2000:107). The most important areas of growth in the ICT sector are forecasted to be in cellular ICT services and products and the Internet (Telcom Africa 2000).

The purpose of this chapter is to explain South Africa's cellular ICT sector. The sector's possible contribution to economic development is identified in section 2.2. South Africa's current telecommunication network and service providers are assessed in section 2.3. In section 2.4 a critical discussion of South Africa's cellular ICT sector is given. The nature of production and forms of trade in South Africa's cellular ICT sector is discussed in section 2.5. Section 2.6 concludes with a summary.

2.2 The role of ICT in the South African economy

ICT services play a key role in any economy – from being an important intermediate input to business, an enabling medium for a range of content providers, a significant item in household expenditure, and finally a source of demand for numerous manufacturing and service industries. In the sections below, this role will be discussed with reference to the contribution of the ICT sector to South Africa's economic growth and ICT products and services as intermediate inputs.

2.2.1 Contribution of ICT sector to economic growth

Roller and Waverman (2000) determined that investments in ICT infrastructure might have significant positive growth effects. For Germany and other OECD countries it was found that the impact of ICT infrastructure on aggregate economic growth was at a compounded annual effect of around 1.2%. Given that the OECD has grown at a compounded annual growth rate of some 1.96%, they found that about one-third of growth could be attributed to investments in ICT (about 0.59%).

Another finding was that for high levels of ICT infrastructure the impact on economic growth is substantially larger. These results imply increasing returns to ICT investments, which is consistent with the presence of network externalities. In particular Roller and Waverman (2000) found a critical mass phenomenon in infrastructure investments, which corresponds to a 40% penetration rate. A 40% penetration rate is often described as a universal service (with approximately 2 – 2.5 people per household), which means that growth effects are significantly higher for countries whose ICT infrastructure has approached universal service. In fact, the impact is twice as large for countries that have achieved universal service. Nowadays most OECD counties have developed their ICT infrastructure so that growth effects are above the critical level.

However, taking a sample of non-OECD countries Roller and Waverman (2000) found that those countries were on average far below the critical level of 40%. In fact, the non-OECD countries have a mean penetration rate of only 4%. This implies that marginal improvements in ICT infrastructure, in non-OECD countries, will not generate the largest possible growth effects. Therefore, non-OECD countries such as South Africa might only realise significant growth effects, if a relatively large improvement in ICT infrastructure is undertaken.

In 1995 ICT contributed around 2.5% of South Africa's gross domestic product (GDP). By 2000 its contribution stood at 5% and should double again to about 10% in five years. This will mean that ICT could in the foreseeable future surpass mining in contribution to GDP (Van der Kooy, 1999:9).

2.2.2 ICT products and services as intermediate inputs

ICT's role as an intermediate to firms has two dimensions:

- as a cost item required to operate a business
- as a strategic and competitive tool

As a cost item, ICT does not appear that significant to most of the economy. It represents only 0.1% of total costs in agriculture and mining, 0.4% in manufacturing industries and 2% in service industries. However, these figures may underestimate the cost importance of ICT because:

- The data network costs are accounted for under the section titled business services, along with other business service items.
- The most recent input-output data available for South Africa is 1993, which may pre-date the Internet explosion, the launch of cellular telecommunications in South Africa, and the growing globalisation of business here.

The combination of these factors may imply that actual expenditure on ICT services could be three to five times of that represented in the input-output tables of 1993. At those levels, price variations in ICT services may impact significantly on the cost and hence the competitiveness of business, as well as the overall price level of the economy.

As a strategic competitive tool, ICT is becoming more and more vital to business globally. Increased globalisation has resulted in the requirement to communicate and transmit vast amounts of data to suppliers, industry consumers and affiliates internationally on a timely basis. The rise of electronic commerce has now established a need in many industries to use ICT networks to deal with the final demand of households. What matters most for an economy is the availability of world-class ICT services at a reasonably competitive price, even if they are not the cheapest (Hodge, 1999a:11).

Growth in the ICT industry has some important tickle-down effects for certain parts of the economy and results in output and employment creation in these sectors. There are two sources of such demand – investment demand and ongoing operations demand.

Table 2.1 Demand for intermediate inputs

SECTOR	INTERMEDIATE DEMAND
Agriculture	65.1
Mining	31.2
Manufacturing	51.9
Service Sectors	48.8
Utilities	77.9
Construction	86.3
International trade	35.5
Catering & Accommodation	18.2
Transport services	49.6
Communication services	72.2
Financial services	63.1
Business services	48.1
Community, social & personal services	28.3
Total	61.4

Source: Hodge, 1998a:25

Figure 2.1 above details the structure of demand in each economic sector in South Africa. It can be seen from this table that intermediate demand is the dominant source of demand for many service sectors. Construction (86% intermediate demand), utilities (78%), ICT (communication) (72%) and financial services (63%) all have share of intermediate demand above the economy average and well above manufacturing at 52%. Transport and business services have lower than expected levels of intermediate demand (around 50% for both). In transport this is due to a sizeable amount of intermediate demand, for trade purposes, and is classified under exports while business services includes real estate services which have a sizeable final demand component (Hodge, 1999a:12).

2.2.3 The multiplier effect

Table 2.3 below shows the output multiplier for a R1 increase in the output of each service sector, broken down by its sectoral impact. The current output multiplier effect for services (1.87) in South Africa is just marginally more than mining (1.8), but significantly below that of agriculture (2.11) and manufacturing (2.39).

Table 2.2 Multiplier effect

	Agriculture	Mining	Manufacturing	Service Sectors	Total Multiplier Effect
Agriculture	1.11	0.07	0.57	0.36	2.11
Mining	0.01	1.04	0.41	0.34	1.8
Manufacturing	0.1	0.08	1.78	0.44	2.39
Service Sectors	0.02	0.04	0.32	1.49	1.87
Utilities	0.01	0.08	0.33	1.68	2.08
Construction	0.01	0.09	0.63	1.65	2.37
International trade	0.01	0.03	0.24	1.51	1.79
Catering & Accommodation	0.2	0.04	0.71	1.48	2.43
Transport services	0.01	0.07	0.35	1.46	1.88
Communication services	0	0.02	0.19	1.36	1.57
Financial services	0.01	0.02	0.19	1.81	2.03
Business services	0	0.01	0.1	1.2	1.31
Community, social & personal services	0.02	0.03	0.32	1.47	1.84

Source: Hodge, 1998a:28.

From the above table it can be seen that business services and ICT have the lowest multipliers by a significant margin at 1.31 and 1.57 respectively. Two-thirds of the second round effect that exists is in other services. Justification for stimulating these two sectors would therefore need to based on their key intermediate role (Hodge, 1998a:28).

2.2.4 ICT as a medium for content providers

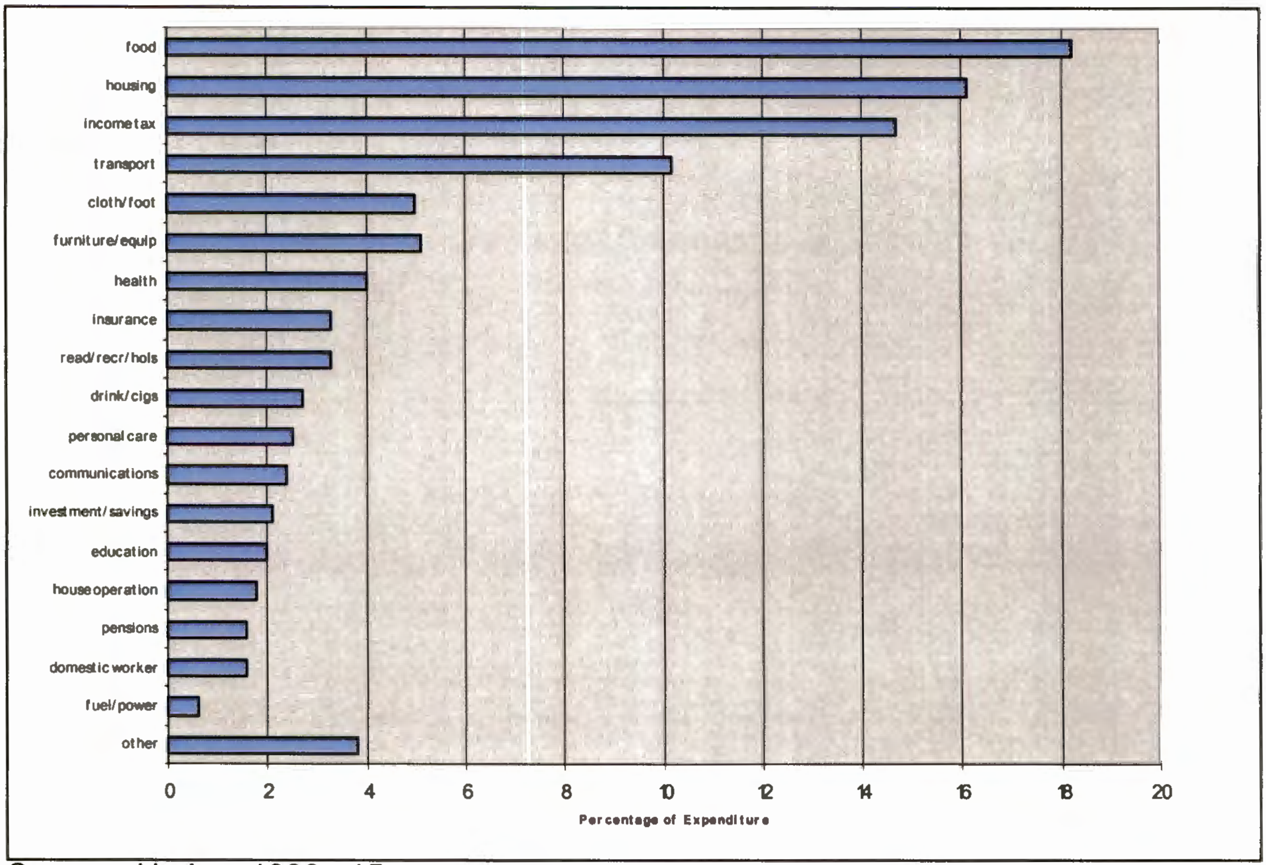
What the analysis of ICT services as an intermediate input or a source of derived demand fails to convey, is that entire industries are based around the existence of ICT services and would not exist otherwise. Too often the ICT services are viewed as a demand derived from growth in other industries or household income. Innovation, cost reduction, quality improvement and independent expansion of ICT services enable the growth and expansion of a large content industry that is transmitted over the ICT infrastructure. This process is one where the ICT industry itself creates demand through innovation and investment. The links to these content industries cannot be portrayed accurately in an input-output table (Hodge, 1999a:14).

The question remains – how big are the multiplier effects on content providers stemming from improvements and expansion of the network.

2.2.5 Household expenditure

Consider Figure 2.1, where the household expenditure patterns as a percentage of expenditure is given for 1995.

Figure 2.1 Household expenditure for 1995



Source: Hodge, 1999a:15

From the above figure it can be seen that ICT did not represent one of the main items that households spend their money on in 1995, but at 2.4% of households income it is still a significant item. In fact, households on average spend more on ICT than on investments/savings, education, house operations, pensions and fuel/power. The size of expenditure is also sufficiently large, so that price movements in the sector may influence both the welfare of consumers and the price level – the consumer price index (CPI). It is to be expected that the percentage of household expenditure in 2000 on ICT, would be more due to the launch of the cellular ICT in 1994 and the increasing availability of the Internet to households.

2.3 Network and service providers in South Africa

Due to deregulation, network and services provided on ICT industry have been separated from each other. The reason for this is that often the network will remain a monopoly because of the expenses and duplication that pushing out another network might involve. Therefore, the only way to inject competition in these instances in to separate the network from the service and introduce competition in the provision of the services on the network. In addition, firms may choose to provide more than one service over their network and so cannot be easily boxed as a provider of one or other service. For this reason a distinction between network providers and service providers can be made.

Network providers operate the infrastructure on which various ICT services are delivered. The range of services that can operate on a particular network depends on the technology of that network.

A means of differentiating between networks is by the medium of transmission used. There are two means – fixed line or mobile. The former uses a physical cable (made of either copper or fibre optic) to transmit information, while the latter makes use of the radio frequency spectrum for transmission. Within each group – fixed line or mobile – the service capabilities of the network depend on the type of transmission equipment and receiving devices used (Hodge, 1999a:5).

2.3.1 Fixed line networks

These networks were historically built to focus on one of three different types of transmission – voice, data or image. The providers focused on voice providing public or private telephony. Technologically, fixed line networks allows two-way transmission between two points on the network by establishing a dedicated line between two points for the duration of a call (Hodge, 1999a:5).

2.3.1.1 Telkom

The ICT system managed by Telkom in South Africa is the largest and most sophisticated network on the African continent, measuring approximately 100 million circuit kilometres, 80% of which are digital. The fixed line network currently consists of 4.6m main lines, of which 128 000 are payphones, the twenty-fifth largest in the world. This translates into a telephone density of approximately 10 per 100 people. However, in rural disadvantaged communities this figure is around 1 per 100 people (Achterberg, 1999:8).

Telkom generates revenues of R20 billion per annum, with total assets of approximately R22 billion (Telkom, 2000). However, network access and coverage is currently inequitable and reflects the priorities of the previous government by extending universal service to white households while ignoring other races. It is this imbalance that the exclusivity period (period granted to Telkom to operate as the sole fixed line operator) is meant to address by giving the current monopolist time to extend the networks significantly through cross-subsidisation. This process will see a total of R50 billion invested over the six-year period. At the end of the exclusivity period, overall teledensity should be closer to 20 per 100 people, with the most gains in previously under-serviced areas (Hodge, 1999a:16).

channels to each cell. This technique allowed frequencies to be reused more often, thus increasing capacity significantly. But it was only in 1971 that the cellular concept became technically feasible by the Federal Communications Commission (FCC). Following a small-cell system trail during 1973 and 1974 in Newark, New Jersey, a service trail of a fully operational cellular system was launched in the Chicago, Illinois, area in 1978. In 1981, the FCC gave approval to offer service, and the first commercial system in the United States was in operation in 1982 and 1983. During the same time period, analogue cellular systems were introduced in Europe, Japan, and other parts of the world.

During the late 1970s and the early 1980s, even as analogue cellular systems were first going into service, research and development of digital cellular systems were in progress. The promise of digital technology included systems with higher capacity, more robust voice quality, and the capability to provide data service. Worldwide interest in specifying digital cellular standards for commercial use was rising. In Europe, where new 900-MHz spectrum had been made available virtually continent wide, a new standardisation body – the "Group Speciale Mobile" (GSM) – was formed in 1982 to study and specify a common, Pan-European standard. The phase 1 GSM (now know as the Global System for Mobile Communications) recommendations were completed in 1990, with first commercial service in 1992 (Zysman et al., 2000:108-112).

South Africa is one of over 120 paid-up members from over 80 countries making use of the GSM technology standard. South Africa operates its GSM network at 900-MHz (GSM 900) (Perlman, 1996:72).

2.4 Service providers in South Africa

The range of services provided in South Africa is no different to that of the ones mentioned above, in particular:

- Public Telephony - local, national, international, mobile national, mobile international, pay-phones

- Data - these are usually referred to as Value-added Network Services (VANS) and
- include email, Internet, EDI (electronic data interchange), paging, managed data network services
- Private telephony - fixed telephony, mobile telephony (e.g. two-way radio, radio bunking)
- Broadcast- public radio, public television, pay television (Hodge, 1999a:7)

A service provider who does not own the network offers the service by either leasing part of the network from the network provider and enhancing this with one or more service component, or interconnecting their own network to others to provide the service. The service component is added for essentially two reasons, firstly because the network provider does not offer the service and secondly if the network provider is seen to be inefficient at that service and the service provider is able to offer it at lower cost or better quality.

A South African example of the former is the cellular industry. The network providers do not retail to the public but instead wholesale network access to a group of approved service providers. These providers in turn offer retail outlets to access customers; they stock and sell the phones and perform credit checks, link the customer to the network and perform all billing and debt collection. Alternatively, service providers offering managed data networks, may lease part of the public network but complement this with their own protocol conversion and data encryption capacity. They may also have some network infrastructure themselves that bypasses aspects of the public network that is incapable of running the service.

In terms of efficiency arguments, a number of possibilities emerge. It could be that a network provider is using dated or inefficient technology at points in the network, which a service provider may choose to replicate and then lease or interconnect to other parts of the network to compete. This may be as simple as the credit and billing component or Internet access via the local telephone network but using a national data network. Alternatively, the large network provider may not be able to adequately price discriminate amongst all niches in the market and a service provider may lease excess capacity in the network for the purpose of niche resale. This is often the case with international or national telephony services providers. The internet provides another example of niche servicing - an important component of what customers seek in service providers is member services such as home page news, links and community information (Hodge, 1999a:7).

2.5 South Africa's current cellular ICT sector

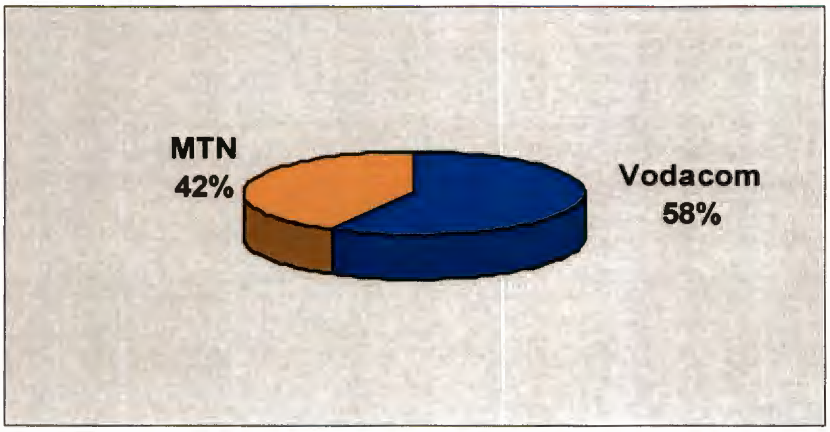
In 1984 Telkom as South Africa's sole ICT operator, offered a limited mobile phone service. This initial analogue service was available to only 11 000 people in Johannesburg, Cape Town and Durban. The briefcase-sized handsets, usually mounted in cars because they were heavy, were expensive at R15 000 (excluding airtime charges).

In 1994 digital phone technology and deregulation lead South Africa to introduce mobile cellular communications. At the time of writing, feature-rich, handheld phones are available countrywide from network providers, MTN and Vodacom, at a fraction (approximately 10%) of the original cost (Bidoli, 1999d:44).

2.5.1 Network operators

With the launch of the cellular ICT's in South Africa in 1994, Vodacom had known eight months earlier than MTN that it would win its license and had begun installing infrastructure around the country. Playing catch-up created serious cash-flow problems for MTN, who had to recapitalize R500m to R1.5bn and was also unable to caught up with Vodacom. In 1998 there were 2.3-million subscribers and the growth from 1997 to 1998 was dominated by prepaid service, which grew by 161% over that period. By 2000 there were almost 4m subscribers, with Vodacom having the largest share of this market (58% of the subscribers), as indicated in Figure 2.2 (Cellular, 2000).

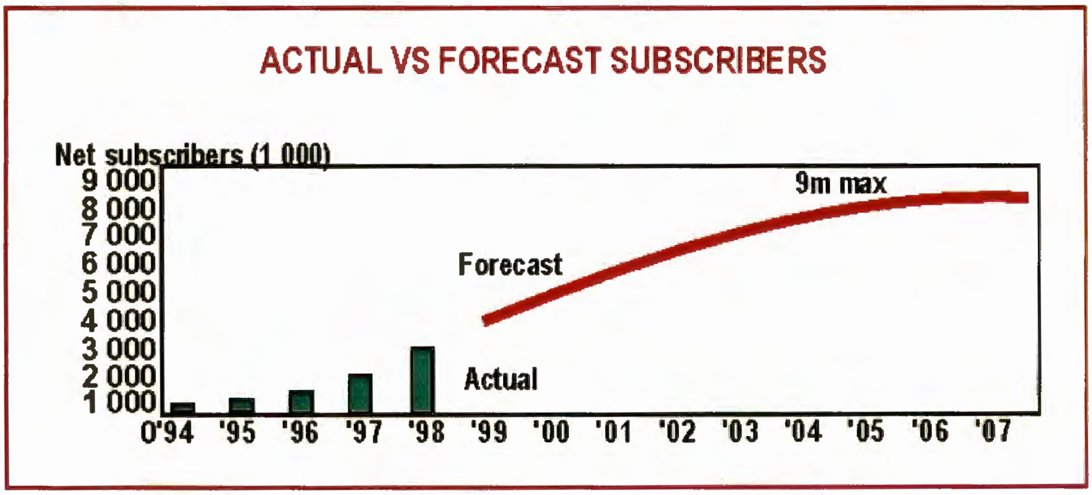
Figure 2.2 Marketshare of South Africa's cellular ICT operators



Source: Cellular, 2000.

Approximately 150 000 new subscribers add to this total each month. This figure is likely to double by 2004 as indicated by Figure 2.3 below. The goal is 7m by 2004, which would mean that 15 out of every 100 people would have access to a telephone. In telephone terms, this places South Africa in the league of middle-income countries, which averaged 14 per 100 (in 1997) and among higher-income countries, which average 19 per 100 (Van der Kooy, 1999:9).

Figure 2.3 Cellular subscribers for South Africa (1994 –2007)



Source: Van der Kooy, 1999:9.

The network operators do not deal directly with the public but wholesale airtime to appointed service providers who in turn retail network access to the public or corporations using their own tariff structures. The service providers currently (the year 2000) appointed to each network are (MTN; Vodacom, 2000):

- MTN network – Autopage Cellular, M-Tel, Nashua, Nedtel, Plassey, Radiospoor Cellular, Sebcom, Supercall, Transtel and TTC.
- Vodacom network – Afritel, Autopage Cellular, Cellphones Direct, GSM Cellular, Nashua, Nedtel, Plessey Cellular, Radiospoor Cellular, Supercall, Teljoy and Vodac.

South Africa has experienced significant growth in the industry of around 50% per annum, since its launch, providing industry revenues of roughly R4 billion per annum. This implies that South Africa is the largest GSM technology network outside of Europe and the fourth fastest growing GSM market in the world (other countries like the USA are using different network technologies). The duopoly of Vodacom and MTN are, by the end of 2000, facing the entrance of a new cellular operator, which will result in an oligopolistic market structure (See chapter 3). Depending on the equilibrium between market participants, this long-awaited licensing of this new operator, may result in an improvement in quality, market penetration and services (Bidoli, 1999d:44).

2.6 Products and services of South Africa's cellular ICT sector

2.6.1 Interconnection charges

Network provision is technology-and capital-intensive. However, because of the technical nature of production, it is also human capital intensive. Network provision is physical capital intensive because of the need to make large investments in a physical transmission network.

Network providers also need to have the technical expertise to adopt the technology in the first place, adapt it to their specific network conditions, integrate it effectively with existing equipment of different ages and origin, maintain and troubleshoot over the life of the technology and gradually enhance its performance to improve productivity. These processes require a high degree of in-house expertise (Hodge, 1999a:8).

The pricing and competitive behaviour amongst network providers are influenced by a number of factors peculiar to network industries (Hodge, 1999a:8). Firstly, the value of a network is related to the number of customers connected to that network. Therefore, it is in the interest of all competitors to interconnect with each other to gain access to as broad a customer base as possible to enhance the value of their respective networks. The ability to interconnect also means that firms can compete with other network providers on one part of their network without having to duplicate the entire network – for instance, firms may compete on long distance telephony by building their own distance infrastructure and interconnecting to a local network to reach the final customers (Hodge, 1999a:8).

The key determination of competition and pricing, is how interconnection is priced. Inter-connection charges are partly determined by the cost of interconnection and transmission of calls, and partly by the market structure of network provision. The latter presents a number of possibilities, each the outcome of negotiation. The possibilities can be described as follows:

- If one network provider has a monopoly in the part of the network that the other network wishes to interconnect with – in this case, if the two networks do not compete in any markets then the outcome may resemble costs more closely. This is unless there is an uneven traffic flow of users of the other network. If the two networks do compete in other segments of the market then there is incentive to deliberately overprice in order to ruin the competitiveness of the other network in the other market.

- If the one network provider faces competition in the part of the network that the other network wishes to interconnect with – in this case, the network can either collude with their competitors in the market to keep interconnection costs high, or price competitively to take paying traffic away from competitors. Competition comes not only from networks of the same technology but also from networks of different technologies. In some cases the competition may not be perfect but at least provides an upper limit under which a monopolist may price over marginal cost.

South Africa's cellular sector can be described as an imperfect competition industry, due to the few network operators. Regulatory tools are used to try to increase competition. These may include setting the price of interconnection or segmenting the market so that no one player has incentive to overprice.

A second feature of the telecommunications sector in South Africa is that once the network is in place, the marginal cost of transmitting one more call or piece of data over the network is negligible, unless it pushes the network to the point of full capacity. This creates a problem on how to price services, including interconnection charges. It has resulted in a range of pricing from a flat monthly fee for local calls or Internet access, to pricing individual calls differently in peak and off-peak periods. It also allowed niche service providers to thrive as they purchase off-peak excess capacity at discounted prices and attempt to resale more effectively to the public in order to make a profit.

The pricing mechanism used by regulators to price interconnection charges is the long run incremental cost (LRIC) of building and maintaining a network, including an average return on capital. This is a difficult process, especially as it relies on information provided by the network provider that one is trying to regulate. Despite the teething problems, this is seen, as the manner in which to price such services in a competitive market when marginal costs pricing is nonsensical (Hodge, 1999a:9).

To protect the Telkom monopoly, the cellular providers are not allowed to make use of any fixed lines other than those from Telkom, and all international services must be routed through the Telkom network. They are free to negotiate international roaming services for when the consumer is out of the country (Hodge, 1999a:24).

Telkom's situation before privatisation (in April 1997) was not unique: international calls had the largest profit margin, then long-distance calls, while local calls were operated at a loss. Competition through call-back services and the cellphone industry lead Telkom to no longer charge per second (Telkom, 2000). At present (2000), the minimum amount charged for Telkom to cellular calls is 46c for the first 17.2 seconds. After this, calls are charged at an additional 2.67c per second. This results in an effective per minute rate of 160c. Instead, Telkom will charge a minimum of 160c for the first minute and 80c for each 30 seconds thereafter. Telkom claims that it is reducing the cost of long distance calls. Long distance calls made from a Telkom telephone to another Telkom phone will be 30% cheaper than those to cellular customers (Bidoli,1999b:97).

The cellular ICT sector offers competition to Telkom, 35% of pre-paid cellular users and 22% of contract users said they did not have a Telkom phone line and were not planning to get one. Their reason was Telkom's poor service record (Bidoli, 1999b:85).

In South Africa the service provider (SP) plays an important role, not only in administrating the customer's accounts, but also in looking after the customer's connection to the network provider. Contracts are designed with a range of versatile services and airtime minute options ensuring that customers get what they want from the connection as they choose their price plan and cellphone. An airtime contract consists of [MTN, 2000; Vodacom, 2000]:

- A fixed monthly charge (for twenty four months); and
- Talktime minutes that are included in the fixed monthly charge or lower standard call rates.

In the current duopoly, MTN and Vodacom, in conjunction with the South African Regulatory Authority (SATRA), agree on a maximum tariff for calls (Gordon, 1998:96). Consider Table 2.3 below, where four Vodacom and MTN airtime contracts are weighed up against each other.

Table 2.3 Airtime contracts of domestic providers

Provider	MTN	Vodacom	MTN	Vodacom	MTN	Vodacom	MTN	Vodacom
Price Plan	AnyTime Off-Peak	Weekend Everyday	Business Time	Talk Business Call	Performer	Talk 100+	Talk 1000+	Talk 1000+
Monthly Subscription	R129.00	R129.00	R169.86	R170.00	R273.60	R280.00	R1000.00	R1000.00
Connection Fee	R95.19	R95.00	R95.19	R95.00	R95.19	R95.00	R95.19	R95.00
Inclusive Airtime Minutes per Month	Up to 120 Off-peak weekdays & weekend	120free min's on weekends and off-peak & special periods.	None	None	Up to 120 anytime	First 120 min's gree	first 1000 min's free	first 1000 min's free
Peak Calls	R2.51	R2.51	R1.48	R1.50	R1.48	R1.50	R1.19	R1.19
Off-Peak Calls	R0.68	R0.68	R0.68	R0.68	R0.68	R0.68	R0.68	R0.68

Source: MTN, 2000; Vodacom, 2000.

The above table gives Vodacom and MTN's monthly subscription, connection fee, inclusive of airtime minutes per month and call rates for each of the different contracts. It is clear from the above table that these two network providers do not compete with each other on a price level. They tend, instead, to differentiate themselves on services and special offers.

In Table 3.5.2 MTN and Vodacom's contracts are compared to British network providers such as Vodafone, BT Cellnet, One-2-One and Orange.

Table 2.4 South African and British airtime contracts

Country	Network	Contract	TalkTime	Activation fee	Monthly fee	Peak	Off-peak
SA	Vodacom	Talk 100+	120	R95.00	R280.00	R1.50	R0.68
	MTN	Performer	120	R95.19	R273.60	R1.48	R0.68
UK	Vodafone	VF 150	150	R372.05	R265.75	R2.13	R0.53
	BT Cellnet	Call 120	120		R265.75	R2.66	R0.53
	One-2-One	One2Anytime 150	150		R159.45	R1.06 - R4.25	R0.21 - R2.13

Source: MTN; Vodacom; Vodafone; BT Cellnet; One-2-One; Orange, 2000.

In the above table, business packages with 120 free airtime were used. Comparing these contacts against each other MTN and Vodacom appears to be internationally competitive. But according to Campbell (1999) South Africa's cellular operators are not internationally competitive and their rates are about the third highest in the world.

The UK is an example of how the entrance of a third and fourth network operator drove down costs. The first two networks in the UK were Vodafone and BT Cellnet. In the first nine years of their existence as a duopoly, call prices were never reduced. In 1994 two new network operators were licensed – One-2-One and Orange. Realising the only way that they were going to get any business was to offer services at lower prices. Which lead to a drop in the UK's cellular tariffs for the first time in nine years (Gordon, 1998:96).

Before November 1996, cellular ICT services in South Africa were fairly exclusive. Customers who wanted to subscribe to services were put through rigorous and inconvenient credit checks. The networks introduced their pre-paid services. People who wanted access to the cellular networks bought a smartcard and paid for it up front. The networks got their money and a whole new market. People who were denied services in the past now had access to them. On MTN and Vodacom, more than 60% of new subscriptions are on the pre-paid system (Gordon, 1998:95). Pre-paid has increased the number of cellular users by more than 20 000 a month (Bidoli, 1998:92). Although both companies claim their pre-paid cervices are ideal for lower-income markets, these services cost more than R2/minute. This has been judged to be expensive (Bidoli & McLeod, 1998:79).

The pre-paid card gives outgoing calls to a Rand value, and a specific number of days access to the network for unlimited incoming calls. Cards can be bought at a wide variety of outlets, and a user can load as many cards as he or she wants. Unfortunately access to an own cellphone is needed. The advantages of pre-paid airtime is [MTN, 2000; Vodacom, 2000]:

- No contracts;
- No credit checks;
- No waiting time; and
- User budget control over amount spent on costs.

Prepaid is less expensive to administer and distribute. The high cost charged by cellphone networks, Vodacom and MTN, to users of prepaid cards will probably be the first casualty in the price war, likely to start when the new mobile phone operator opens for business (Laing, 1999:53)

2.6.2 Value added services

According to Gold (2000) the telecommunications industry fails to meet the expectations of users and a disparity exists between services offered currently by the telecommunications operators, and what they think their customers want. This report of Teligent determined that that more than 90 percent of the telecommunications operators acknowledge the need for high investment in value-added services, but are not able to respond sufficiently to meet market demand. Deregulation has increased competition among telecommunication providers, intensifying the need for better management of customer relationships (Arthur Andersen & Proxima Systems, 1999:1).

Both MTN and Vodacom give an innovative and easy to use range of services to make cellphones much more than just mobile means of making and taking calls. These services are anything from personal answering service and message taking, to a mine of useful information, to a lifesaver in an emergency situation. It's a money-saving, time saving tool that has become so indispensable for home executives as it is for businessmen. The standard services at the time of writing are:

- Conference call;
- Voicemail;
- Faxmail;
- Short message service (SMS);
- Mobile data;
- Emergency service;
- Calling line identity;
- Call forwarding;
- Call barring;
- Call waiting & call holding; and
- International roaming.

In addition to the above some of the other current services include:

- Reuters financial;
- Legal assistance;

- Tax assistance;
- Directions;
- Directory services;
- Computicket telebookings;
- Dual call;
- Wake-up call;
- Weather lines;
- Daily motivation;
- Medical information; and
- Technicon & university examination results.

Vodacom added a 'Dial A-Teacher' service, where scholars can phone for advice on their schoolwork (MTN, 2000; Vodacom; 2000).

2.6.3 Trade in communication services

The production of and trade in high technology product has always been seen to be important for both developed and developing countries. For developed nations these products are a source of significant exports, off-setting their loss of competitiveness in traditional low technology products. For developing nations, mastery of these products represents a necessary step on their industrialisation path. It is also an important means of protecting their external balance as their own consumption of these products burgeons and as they too lose competitiveness in traditional sectors as wage levels rise in their economies. Additionally, the high tech sectors are the fastest growing in the world economy and so represent a significant opportunity for growth.

South Africa has a significant trade imbalance in high technology products ($3 747.4 million in 1995) due to the:

- Distorted incentives favouring the servicing of the local market;
- Lack of economies of scale (See chapter 3);
- Domination of multinationals interested in local sales;
- Good but not widespread technological capabilities;
- Sanctions before 1994 and a closed economy; and

- Protected and hence unnaturally profitable traditional sectors drawing capital away from high tech.

An analysis of the actual products traded, reveals that computer and telecommunications products not only account for almost half of imports (48%), they are also the fastest growing (Hodge, 1998b:1).

Trade in services can occur through four possible modes of supply – cross-border supply, consumption abroad, commercial presence and the presence of natural persons.

Cross-border supply takes place through international interconnection charges and leasing of cross-border transmission lines. Telkom has a monopoly on international services in South Africa (Hodge, 1999a:18).

2.6.3.1 Commercial presence and presence of natural persons

Opening market access through commercial presence represents one of the least risky paths that can be taken by a liberalising economy as it combines many of the benefits without much of the costs. The advantage of trade via commercial presence is that production must take place in the host country, which means that there is no domestic output, and employment losses from trade – only a transfer of ownership. The country still gains from technology transfer and an increase in competition. The additional benefit of commercial presence is that it involves foreign investment, freeing local capital to pursue other opportunities in the domestic market and raising the overall level of investment in an economy (Hodge, 1999b:5).

South Africa is low on the list of priorities for international telecoms companies wanting to expand offshore. Instead of attracting international investors with regulations and policies that show them clearly where they stand, South Africa authorities are doing the opposite. Political infighting and confusing messages from the regulatory and political authorities have done little to inspire confidence among potential investors (Bidoli, 1999a:81).

2.6.3.1.1 Imports

Foreign participation in the domestic telecommunications industry is a recent phenomenon and still remains limited through regulatory restrictions. Foreign participation in the cellular communication sector is limited to a cumulative maximum of 30% but holdings in individual firms may exceed 30% as long as participation across all firms in the market in not greater than 30% (Laing, 1998:19).

Vodacom's foreign shareholder is Vodafone UK with a stake of 31.5%. Local shareholders in Vodacom include Telkom (50%), Rembrandt (13.5%) and Descarte Investments (5%) (Laing, 1998:19).

MTN no longer has a foreign shareholder after Cable and Wireless UK sold their 25% stake in 1999 to local group Johnnic and Transtel. The apparent reason for the sale was to take the large short-term gains, which have been made, and use that to dig, further into markets (Laing, 1998:19). As from September 2000 MTN is domestically wholly owned by M-Cell, which is a subsidiary of the Johnnic group (M-Cell, 2000).

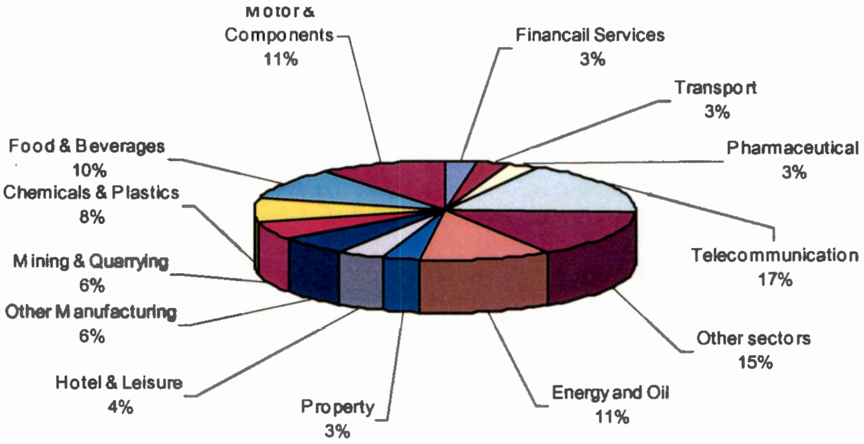
Solely foreign providers provide satellite networks with a minor shareholding by Telkom in Intelsat and Inmarsat. The Department of Communications has initiated plans to examine the feasibility of launching a regional satellite owned by industry members from the region. However, plans are not far advanced and if followed up would take many years to unfold. Signal local firms only operate distribution, of which Telkom is the only one for telecommunications services, due to its monopoly (Hodge, 1999a;19).

2.6.3.1.1.1 Foreign direct investment

Foreign direct investment (FDI) is a form of foreign private investment and a developing nation needs FDI to use the resources of the world market to improve their economic competitiveness. The cumulative FDI into South Africa in the period 1994 to 1998 amounted to almost US $5 billion, growing at an average of 46% per annum. But by comparing South Africa with other emerging economies, it is clear that FDI flows into South Africa have been small in value terms (Du Mhango, 1999:1-6). FDI is needed to supplement domestic investment in South Africa. South Africa's savings rate of 16 percent of gross domestic product (GDP) is considered poor; thus a substantial foreign investment is required (Soyode, 1999:5).

Consider Figure 2.4, where the sectoral distribution of FDI inflow in South Africa is given from 1994 to 1998.

Figure 2.4 Sectoral breakdown of South Africa's FDI



Source: Du Mhango, 1999:5.

From the above figure it can be seen that FDI into South Africa by value is concentrated in the telecommunication sector (17.5%), suggesting that the main motivation for FDI into South Africa at present is to capture the domestic market.

2.6.3.1.2 Exports

The entry of international firms into South Africa and the liberalisation of telecommunication markets elsewhere in the world have provided an incentive to South African firms to enter foreign markets. The pattern of exports shows weapons is the largest contributor (36.5%) but there is a far more balanced product structure with high and growing shares for computers and telecommunications (20.9%) (Hodge, 1998b:1-2).

MTN has been expanding significantly into Africa while Vodacom has been slower off the mark. This difference may have a considerable amount to do with difference in ownership. Vodafone (31.5% shareholder in Vodacom) has several licenses in Africa and Vodacom has admitted that it would not bid in competition to them (Hodge, 1999a:20)

By the end of 1999 MTN had invested a total of $110m in networks in Africa, and particularly in the following countries: Rwanda ($20m), Swaziland ($20m) and Uganda ($70m). In each case MTN has entered the market with local partners. The customer base is 7 000 in Rwanda and 35 000 in Uganda (Bidoli, 1999c:66). MTN is also finalising an investment in Nigeria, which it sees as potentially profitable due to population size. Other markets, which MTN has expressed an interest in, are Kenya, Côte d'Ivoire, Tanzania, Ghana and Senegal. The company sees the strategy as both providing long-term growth once the South African market saturates, and also as a means of reducing costs through building regional networks which provide bulk purchasing power. In contrast, Vodacom only has an investment in Lesotho with 6500 customers and was also recently approved to operate in Tanzania (Laing, 1999:53).

2.6.3.2 Consumption abroad

Consumption abroad requires the movement of the consumer to the country where the producer resides (Hodge, 1999b:7). Vodacom and MTN have numerous international roaming agreements. MTN and Vodacom have agreements in about 50 countries and 120 networks each (MTN, 2000; Vodacom, 2000).

2.6.4 Regulations applying to South Africa's cellular ICT sector

2.6.4.1 Background and objectives of current regulation

Interest in the nature and extent of government intervention in trade in services has grown rapidly in recent years. From the domestic perspective the focus has been on the effects of government regulation on the distribution of resources and on consumer choice. From the international perspective the focus has been on government restriction of market access and barriers to trade in service. Because of the impact of government regulation of internationally traded services, there have been proposals for the liberalisation of restrictions on service (Sampson & Snape, 1985:171).

The restructuring of the telecommunications market in South Africa started in the late 1980s when the public telecommunications providers (Telkom) began to be managed as a commercial enterprise. The changes were due to changes internationally and the fact that inefficiencies in the delivery of communications services locally resulted in poor returns to capital and rising debt – hindering its ability to serve the needs of a growing modern economy (Hodge, 1999a:20).

After Telkom was incorporated in 1990, a study by Coopers & Lybrand was commissioned to examine the policy options for restructuring the industry to maximise the economic and social benefit, including improving telephone penetration, affordability and service levels. The recommendations of the report, released in 1992, included most of the elements of the eventual regulatory regime enacted in the Telecommunications Act of 1996. These included an exclusivity period for Telkom, resale of capacity for voice traffic prevented for 3-5 years, stringent license conditions for Telkom during this period of exclusivity, and the establishment of an independent regulator. It also included a call for some immediate steps to be taken – including the issuing of two mobile communications licenses and the opening up of the VANS and the customer equipment markets.

The government acted on the mobile licenses (issued June 1994) and the opening of the VANS and customer equipment markets (1993). However, the major revamp of the regulatory regime would have to wait for a change in government and secondly a process of broad consultation through a Green/White Paper process. The White Paper on Telecommunications Policy was released in March 1996 and the ensuring legislation was enacted in November 1996. This meant that although a five-year monopoly period was recommended for Telkom back in 1992, that monopoly period only began to take effect in 1997 (Hodge, 1999a:21).

The Green/White Paper process did, however, contribute to the final regulatory outcome because it included a number of objectives other than increasing competition, efficiency, innovation and profitability in the industry. In particular it called for the following social goals to be part of the objectives of a telecommunications policy:

- Promote the universal and affordable provision of telecommunication services;
- Ensure that, in relation to the provision of telecommunication services, the needs of the local communities and areas are duly taken into account;
- Encourage ownership and control of telecommunication services by persons from historically disadvantaged groups;
- Encourage the development of human resources in the telecommunications industry;
- Promote small, medium and micro-enterprises within the telecommunications industry.

The most important economic goals expressed in the objectives were:

- Promote the provision of a wide range of telecommunication services in the interest of the economic growth and development of the Republic;
- Encourage investment and innovation in the telecommunications industry;
- Encourage the development of a competitive and effective telecommunications manufacturing and supply sector;
- Ensure fair competition within the telecommunications industry; and
- Ensure efficient use of the radio frequency spectrum.

Most countries have benefited from the demonstration effects of a select group of industrial countries that have pursued such reforms to date. This has served to reduce the regulatory risks of opening these markets and has shown that there are significant net benefits for countries. It is for this reason that countries, like South Africa, have already moved down this path without significant prodding from the international trading system. Delays in implementation usually stem from the political economy difficulties faced by any reform process. The benefits for the industry itself stem from the following sources:

- Reduction of price-cost margins – the introduction of competition limits the market power of industry players;
- Static efficiency gains – the introduction of competition should see a reduction in the level of X-inefficiency in the market as firm adopt domestic best practice and inefficient producers are squeezed out;
- Scale efficiency gains – the expansion of the market through price reductions will impact positively on scale and result in efficiency gains if scope for further scale economies exit;
- Dynamic innovation gains – the introduction of competition in components of the sector should result in a higher rate of process and product innovation as firms strive to gain market share; and
- Potential trade gains – regulatory reform will result in opportunities for domestic entrepreneurs to establish a presence in the industry and make the incumbent parastatal a commercial concern.

The cost of this efficiency drive is potential employment loss in the reforming sector. In addition, the drive for productivity improvements will alter the structure of employment. The result will be a shift in demand towards higher skilled workers, leaving lower-skilled workers to bear the brunt of job losses (Hodge, 1999b:2-3)

2.6.4.2 Independent regulatory body

An important component of the new telecommunications regulation was the establishment of an independent regulatory body, a function that used to reside with the Department of Communications and Telkom. The new body, the South African Telecommunications Regulatory Authority (SATRA), consists of 3 to 5 councillors and one chairperson, all Presidential appointments based on the recommendations from a parliamentary committee. The Act specifically excludes people who may have conflicting interests such as a financial interest in the industry itself, and demands that the committee be representative of the population and the chairperson five years. The council can appoint a sizeable staff and occasional consultants to assist it in performing its function (SATRA, 2000).

The purpose of SATRA is to regulate the industry in terms of the Telecommunications Act (1996) and pursue any new policy directions that are issued by the Minister of Communications as long as they are consistent with the broad objectives expressed above and if prior consultation has taken place.

The Telecommunications Act recognises the licences of Vodacom and MTN to operate a cellular network. It also required that SATRA investigate the feasibility of issuing more licences. This has occurred and one more licence was awarded in November 1999. The Act allows SATRA to establish licence conditions for any licence that helps achieve the objectives lay out above. Thusfar they have included limitations on foreign ownership, requirement to have a Black empowerment partner, economic development through local purchasing and exports, universal service obligations and human resource development.

The scheme developed for the cellular licences was to attach values to certain development actions for which the network operators were credited. The requirement was for a credit amount and the licence holder could choose the mix of activities that fulfilled this obligation. In addition, there were some specific service conditions:

- MTN and Vodacom were required to install 7 500 and 22 000 community service telephones respectively to under-serviced areas over a period of five years;
- Achieve population coverage of 60% within two years and 70% within four years; and
- Not increase prices in one year beyond the CPI.

The conditions for a new licence have similar requirements but have been relaxed to attract international investors. In particular, the new entrant will be allowed domestic roaming on the MTN and Vodacom networks to provide them with extensive coverage while their network is being tolled out and they will be protected from further new entrants for five years. There is also no specified shareholding size for the required empowerment partner (Hodge, 1999a:21-24).

However, the implication of the Minister setting policy means that many of the dates for which segments of the market are opened for competition, and the number of new entrants, are left to the discretion of the Minister – the Telecommunications Act of 1996 does not put specific dates to the process of liberalisation. The regulator merely calls for bids and issues licenses according to fair and transparent criteria (Perlman, 1996:70).

2.6.4.3 Universal service agency

The Universal Service Agency has been established with the goal of investigating and recommending ways to achieve universal service. This includes defining what the universal access or service targets are. The Agency has two tools with which to influence universal service:

- They may recommend license conditions that help bring about universal service/access. Currently, both the cellular network providers and Telkom have significant obligations to provide service to under-serviced areas. New entrants will be given similar conditions to ensure no competitive advantage.

- The Universal Service Fund was established to subsidise "needy persons towards the cost of the provision to or the use by them of telecommunications services", and to repay Telkom and other license holders with universal service obligations for extending their service to poorly or unserviced areas and communities (Hodge, 1999a:25).

According to O Siochru (1996), either monopoly or competitive service providers can address the critical empirical determinants of the growth of universal service. The means by which they are addressed varies, sometimes in complex ways, among different regimes. But an important point is that their positive influence on universal service is determined far more by national characteristics and international factors than by the type of regime.

The final outcome may be influenced far more by how effectively these policies are devised and implemented than by which of them is chosen.

2.6.5 Regulations governing competition and trade in other countries than South Africa

Wallsten (1999), considered information from 30 countries in Africa and Latin America form 1984 to 1997, such as main line penetration, telecom employees per main line and the price of a three-minute local call, the impacts of liberalisation through competition, privatisation and conduct regulation. The findings of this research is that:

- Competition (structural regulation) has tangible benefits on performance;
- Privatisation by itself has a negative impact on performance; and
- Privatisation combined with the establishment of conduct regulation has a positive impact on performance.

A key finding is that structural regulation is a key driver to improving performance and, as such, governments that are considering granting a period of exclusivity to the incumbent as part of the privatisation process should think carefully (Alexander & Estache, 1999:11).

Rapid changes have taken place in Chilean telecommunications industry that have affected diversity and provision of services. The traditional providers of telephone service, with their limited expertise, financial base trained personnel, did not have the capacity to make these new technologies a reality in the time frame envisioned by policymakers. The position was taken that deregulation would level the playing field and allow newcomers to fill the gaps. As a result, the traditional providers of telephone service are no longer alone in the national quest for modernisation. They have been joined by a myriad of local and foreign companies with expertise in the provision of cable, long distance, radio networks, Internet, and satellite transmission. The reform in the telecommunications industry lead that the demand for telephones was being met. Further, this increase was more than just meeting the natural growth of the population (Rosenblut, 1998: 565).

deregulation network and services provided on ICT industry have been separated from each other in South Africa.

In section 2.5 South Africa's, current cellular ICT sector was examined. Firstly, from Telkom's limited mobile phone service till in 1994 when digital phone technology and deregulation lead to South Africa's introduction of mobile cellular communications. Today, feature-rich, handheld phones are available countrywide from network providers, MTN and Vodacom, at a fraction of the original cost. In 2000 there are almost 4m subscribers, with Vodacom having the largest share of this market (58% of the subscribers). South Africa has experienced significant growth in the industry of around 50% per annum, since it's launch, providing industry revenues of roughly R4 billion per annum. Making South Africa the largest GSM technology network outside of Europe and the fourth fastest growing GSM market in the world.

In section 2.6 this industry's nature of production and forms of trade were analysed. As the duopoly of Vodacom and MTN are, by the end of 2000, facing the entrance of a new cellular operator which will result in an oligopolistic market structure. Depending on the equilibrium between market participants, this long-awaited licensing of this new operator thus may result in an improvement in quality, market penetration and services.

The equilibrium between market participants depends on the market structure the participants are in. In the following chapter South Africa's cellular ICT market structure will be examined.

Chapter 3: Imperfect competition in South Africa's cellular ICT sector

3.1 Introduction

In the previous chapter South Africa's cellular ICT network operators were examined. There are currently (2000) two cellular network operators (MTN and Vodacom). Deregulation has lead to the licensing of one more cellular operator license. Vodacom and MTN are now (2000 or 2001) facing the entrance of the third operator. Depending on the equilibrium between the operators, the entrance of the third operator will have a positive effect on South Africa's cellular ICT sector and the sector's contribution to economic development. The equilibrium between the operators depends on the market structure the network operators are operating in.

In this chapter South Africa's cellular market structure will be examined. In section 3.2 imperfect competition is defined and explained through non-cooperating and cooperating theories. In section 3.3 the economic welfare implications this sector has on the economy are derived. In section 3.4 South Africa's cellular ICT sector's structure is examined. Section 3.5 concludes with a summary.

3.2 Theory of imperfect competition

Imperfect competition (oligopoly) is synonymous with competition among few, as only a small number of firms supply a dominant share of an industry's total output. Duopoly is a market structure where only two firms supply the total industry's output (Malone, 1998:30).

A possible reason for this is that the optimal size of firm, the size at which average cost is minimized, is so large that there is only room for a few such firms. The situation differs from perfect competition because each firm is large enough to have a significant effect on the market price. It also differs from monopoly because there is more than one firm. It differs from monopolistic competition because the firms are few enough and their products similar enough that each must take account of the behaviour of all the others.

As far as their customers are concerned, oligopolies have no more need to worry about strategic behaviour than do monopolies. The problem is with their competitors. All of the firms will be better off if they keep their output down and their prices up. But each individual firm is then better off increasing its output to take advantage of the high price. According to Friedman (1990) there are at least three different possible outcomes:

- The firms might collude and form a cartel, coordinating their behaviour as if they were a single monopoly.
- They might behave independently, each trying to maximize its own profit while somehow taking into account the effect of what it does on what the other firms do.
- Finally, and perhaps least plausibly, the firms might decide to ignore their ability to affect price, perhaps on the theory that in the long run any price above average cost would pull in competitors, and behave as if they were in a competitive market.

3.2.1 Non-cooperating models

3.2.1.1 The Cournot assumption

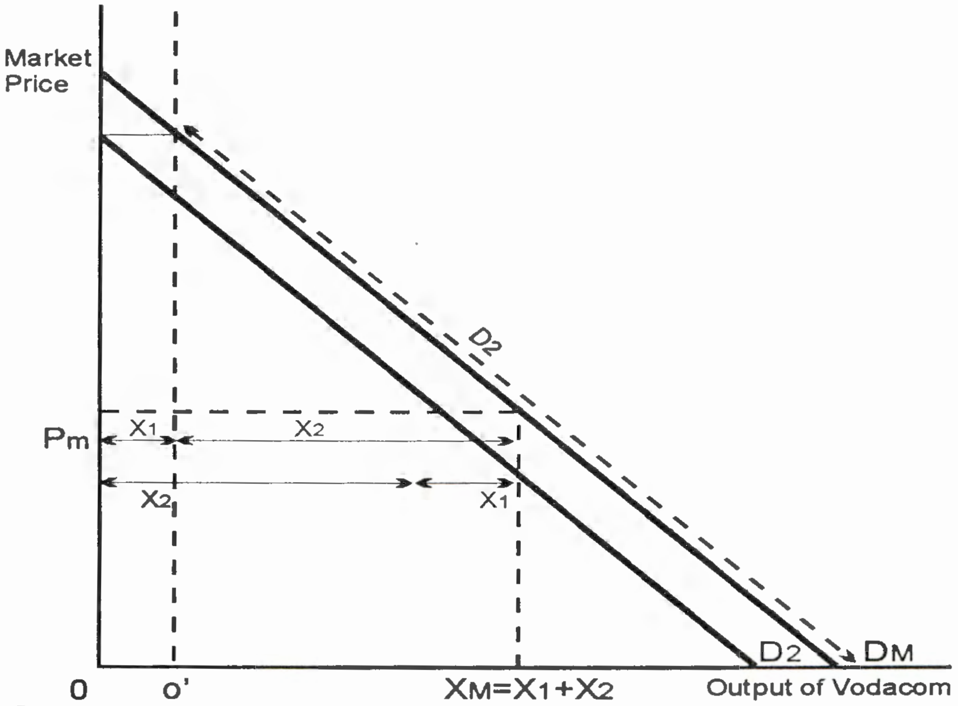
The first and still one of the most widely cited models of non-co-operative oligopoly behaviour is the Cournot model, developed by the French mathematician Augustin Cournot in 1838. The Cournot model is the fundamental model used to study strategic interactions among quantity-setting firms in an imperfectly competitive market (d'Aspremont & Ferreira, 1991:1). In the last two decades, Cournot-based models were used to analyse various real-world phenomena. A proper understanding of the Cournot model of imperfect competition and strategic interactions among firms in various contexts is thus essential (Sarkar & Barnali, 1998:118).

Cournot used a simplified market model where there are only two producers, that is, a duopoly, with identical marginal cost schedules, assumed to be equal to zero. These firms face a downward-sloping linear demand curve, and seek to maximise their respective profits independently. The crucial Cournot assumption is that in determining the profit-maximising level of output, each firm will consider the current level of output of its rivals as given, regardless of its own output, that is, conjectural variation is zero. In a duopoly context, a conjectural variation describes one oligopolist's conjecture regarding the other's response to its own decision. Marginal revenue depends on the firm's share of industry output as well as the market price and demand elasticity (Roberts, 1984:374). Efficiency depends on the curvature of the demand function. If the firms face a concave demand function, they will produce a greater percentage of the efficient output level than if demand had been convex (Malueg, 1994:1-10).

The crucial Cournot assumption is that in determining the profit-maximising level of output, each firm will consider the current level of output of its rivals as given, regardless of its own output, that is, conjectural variation is zero. What is useful about this model is that although the Cournot-type conjectures need not always be correct, they provide an adjustment process that will guarantee that these same conjectures will, indeed, be fulfilled and Cournot equilibrium will, eventually, be reached. In other words, eventually, each oligopolist's conjectures regarding its rival's level of output will be correct and the resulting respective current levels of output will be the profit-maximising ones (Antoniou, 1993:291).

According to Cournot each rival's level of output will remain constant, regardless of the level of output of the opponent (Sarkar & Barnali, 1998:2). Consider Figure 3.1, where the demand facing 'a Cournot-type' duopolist is derived. To illustrate the working of the Cournot model, assume that one duopolist is Vodacom and duopolist two MTN.

Figure 3.1 Cournot demand function



Source: Antoniou, 1993:292.

Figure 3.1 derives the demand facing a 'Cournot-type' duopolist. Assuming that the market demand is D_M and the market price is equal to p_M, then if Vodacom produces x_1 and MTN, x_2, they will both produce a total of $x_M = x_1 + x_2$. In order to derive the demand function facing MTN under the Cournot assumption, that is assuming that x_1 remain constant regardless of x_2, we have the choice of two equivalent techniques:

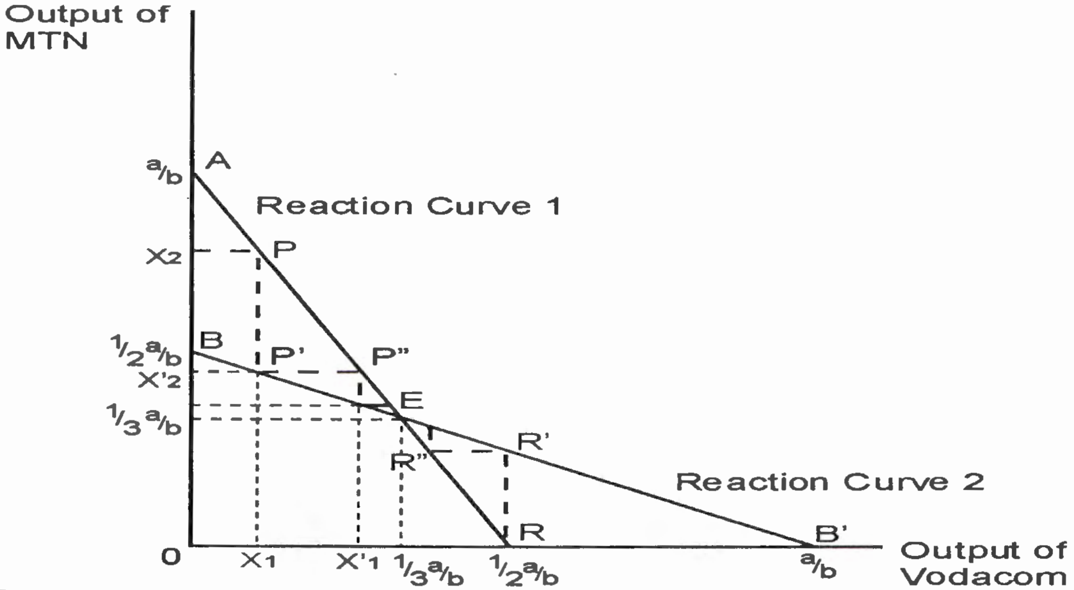
- One can either shift the vertical axis to the right by x_1, so that the new origin now becomes O'; or
- One can shift the demand facing MTN.

Both methods give the same result and could be used to derive the demand facing Cournot-type duopolist one (Vodacom).

The Cournot assumption that the duopolist's conjectural variation is equal to zero implies that each duopolist behaves as a monopolist on the relevant segment of the market demand and therefor will choose the level of output for which marginal cost (MC) equals marginal revenue (MR). Both duopolists have the same conjectural variation, implying they will have identical curves.

Consider Figure 3.2, where two such hypothetical reaction curves are depicted. These curves are the relationship between the rival's possible levels of output and the corresponding alternative optimum choices adopted.

Figure 3.2 Cournot reaction curve



Source: Antoniou, 1993: 293.

In the above figure two such hypothetical reaction curves are depicted. Notice that given Cournot's assumption of linear market demand curve (p = a – bX) and MC = 0, they will also be linear. Thus under these conditions it can be shown that reaction curve 1 shows that if the current level of output of MTN is equal to a/b, then Vodacom will not produce anything, point A. Reaction curve 2 indicates at B, that if Vodacom does indeed produce O, then MTN will only produce (1/2) (a/b). Alternatively, if MTN produces nothing, then Vodacom will produce (1/2)(a/b), point R, but Vodacom must produce a/b in order to 'persuade' MTN not to produce anything, point B".

Clearly, both these sets of outputs cannot represent Cournot equilibrium, as both firms do no produce the level of output anticipated by their rival, which forces them to revise their own levels of output continuously. In the Cournot model is that equilibrium will be reached eventually. Indeed, let the current level of MTN be x_2, Vodacom will consider that level as given and point P on its reaction curve indicates that Vodacom will produce x_1. However, if this happens, MTN will change its original output to x_2', as indicated by point P' on its own reaction curve.

Vodacom must therefore reconsider its own output as the current level of output of MTN has changed from x_2 to x_2'. Notice that the output of Vodacom gradually increases, whilst that of MTN gradually decreases. Eventually, this adjustment process will lead to point E where MTN currently produces (1/3)(a/b). However, this level of output of Vodacom also coincides with the level of output anticipated by MTN, who therefore has no reason to change its own current level of output. Thus, at point E where the two reaction curves intersect, a Cournot equilibrium is reached where both firms produce the level of output anticipated by their rivals, who therefore 'ceteris paribus', have no reason to change their respective current output.

This is a fundamental result in oligopoly theory and thus deserves some clarification:

- The starting point of the adjustment process is irrelevant to the result. Thus, if the initial point had been R, the adjustment path would have been, R, R', R", etc, but the Cournot equilibrium would have been the same.
- The respective Cournot equilibrium levels of output for the two firms must be equal as they are facing the same industry demand and have identical costs.
- Under the model's assumptions, each duopolist will produce less than the competitive output (in fact 1/3) and both will produce more than a monopolist would have produced, namely 2/3 as opposed to ½ of the competitive level.
- The most common criticism levelled against this model is that Cournot-type firms 'do not learn from their past mistakes'. Eventually, the Cournot oligopolists are vindicated in their expectations (Antiniou, 1993:291-295).

The output under a Cournot oligopoly lies between the competitive output and the monopoly output, and the Cournot output converges to the competitive output as the number of firms increases (Sarkar & Barnali, 1998:118).

In the case of Cournot competition, a marginal contraction is strictly beneficial (strictly harmful) if and only if the number of firms in the designated subset exceeds the "adjusted" number of firms outside it by strictly more (strictly less) than one. The adjustment factor is unity when cost and demand functions are linear but, more generally, depends on the convexity of the cost and demand curves. Thus, a marginal contraction of two firms in a triopoly (three firms) has no effect on the profits of firms in the subset if cost and demand functions are linear. If instead cost is linear but the inverse demand function is strictly concave (strictly convex), a marginal contraction will decrease strictly (increase strictly) profits (Gaudet & Salant, 1991:658).

Furthermore, firm entry, to the extent that it increases market output and lower market prices, can increase social welfare, if the elasticity of output with respect to the number of firms is greater than one (Price, 1995:69).

3.2.1.2 The Stackelberg model

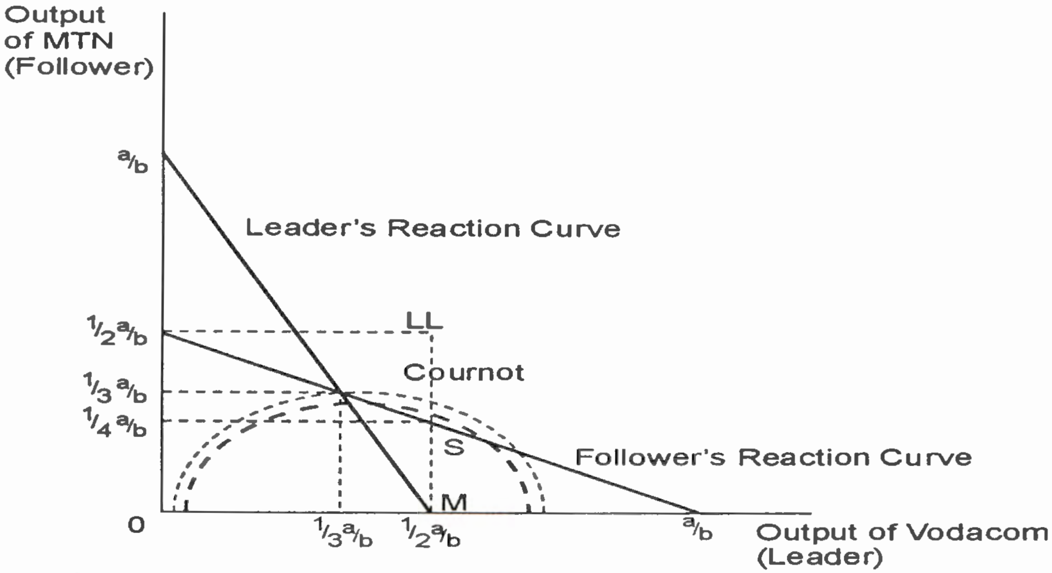
One of the assumptions of the Cournot model is that the duopolists have similar conjectural variations and strategies. In particular they both take their opponent's output as given and maximise their profits with the remaining demands, that is, they both move along their respective reaction curves. However, the German economist Heinrich von Stackelberg (1952) has suggested an alternative assumption.

In the duopoly case with two equal-size firms, one of the firms may decide to take advantage of its relative size, that is half the market, and adopt a different strategy than the one implied by Cournot.

In particular, being aware of the effect that its own level of output has on the market price, and therefore on the optimum level of output of its opponent, it may adopt a 'leadership role'. This means that it will choose the level of output that maximises its profits, given the reaction curve if its' rival. Once the leader has chosen the profit-maximising level of output, the rival becomes a 'follower', who will take the leader's output as given and then find the level of output that maximises its own profits (George & Joll, 1986:144).

Indeed, if Vodacom decides to adopt the leadership role, then what it must do is to find the level of output that will place it simultaneously on the highest isoprofit line and MTN's reaction curve. Where the isoprofit line is a locus of levels f outputs for the two firms for which the profits of Vodacom remains constant, that is, its isoprofit line. Consider Figure 3.3.

Figure 3.3 Stackelberg reaction curve

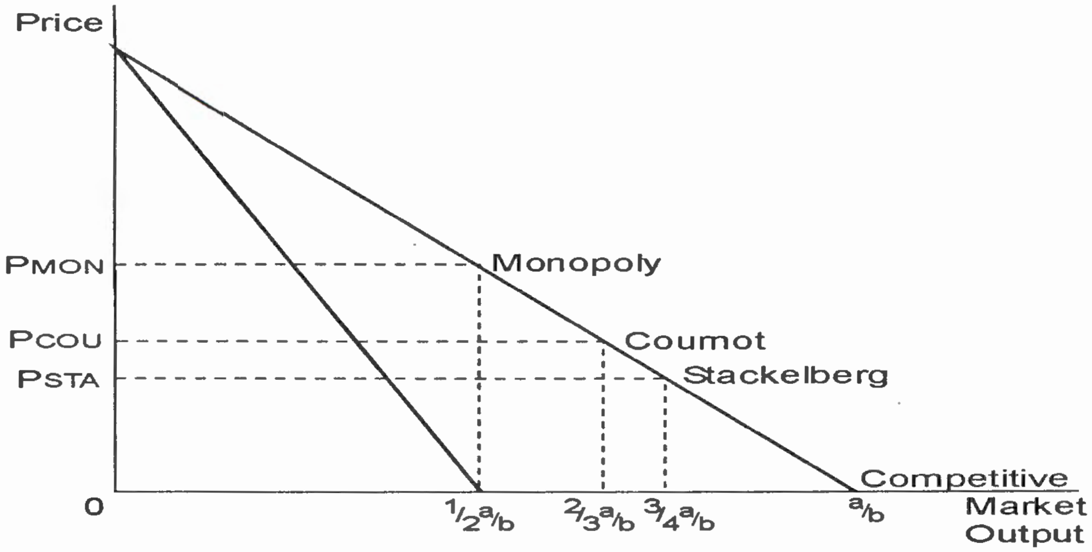


Source: Antoniou, 1993:298.

Maintaining all the other assumptions the reaction curves of the two firms from Figure 3.2 can be reproduce in Figure 3.3, along with the isoprofit lines of Vodacom. Recall that the Cournot equilibrium is at point C, where the two reaction curves intersect, the profits of Vodacom increase as the isoprofit lines approach the horizontal axis, and the competitive level of output is equal to a/b, whilst the respective monopolist and Cournot levels are ½ and 1/3 of that. Thus Stackelberg leader (Vodacom) will choose point S where the 'lowest' isoprofit line is tangetial to the follower's (MTN) reaction curve.

In the Stackelberg model the conjectural variation Vodacom, that is, $\Delta y2/\Delta y1$ is equal to –1/2, that is, the slope of MTN's reaction curve, and the optimal level of output will be the monopolistic level, that is, ½ (a/b). MTN, whose conjectural variation is equal to zero, must make do with the rest of the demand, and will thus produce where the remaining MR curve equals MC (= 0), that is, ¼ of a/b, or half the output of the leader. Consider Figure 3.4.

Figure 3.4 Industry outputs for market structures



Source: Antoniou, 1993:299.

In Figure 3.4 the alternative levels of the industry output are compared under the different behavioural assumptions. It is clear from the figure that the Stackelberg firms combined produce more than their monopoly or Cournot counterparts, at a lower price, but less than the competitive level.

It is clear then that in this setting Vodacom has an advantage over MTN since it produces 2/3 of the market output and therefore earns 2/3 of the industry profits, which here equal $p_{STAC}(3/4)(A/B)$. This implies that both firms will have an incentive to attempt to assume the leadership role, if given the opportunity to do (Antoniou, 1993:297-299).

It is not to say the von Stackelberg leader will earn a higher profit. Gal-Or (1991) found that in a duopoly, the follower could expect to earn a higher profit than the leader for any finite conditional variance of the signal. Shinkai (2000:303), went one step further, analysing a three-player game showing that not only that Firm 2, the second mover, earns the lowest expected profit, but also that Firm 3 earns more than Firm 1 does.

Over the past two decades, only a few attempts have been made, so far, to analyse Stackelberg oligopoly models with incomplete information. In a study by Spiller and Favaro (1984:253), evidence is provided supporting models in which the threat of entry affects the strategic behaviour of incumbent firms.

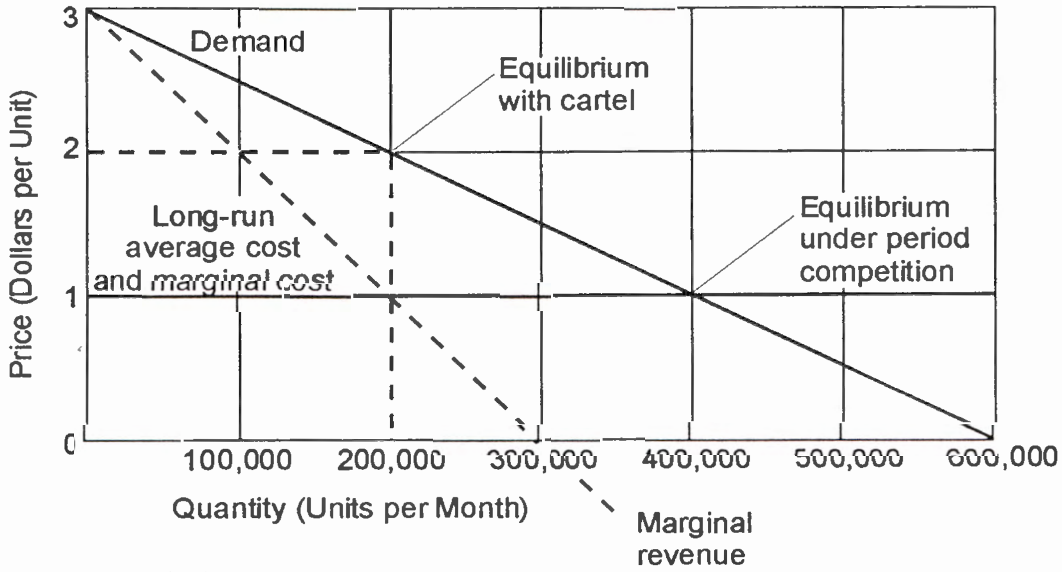
They could not reject a model of the von Stackelberg type in which the large firms behave as dominant ones "vis-à-vis" the small firms and in which the small firms do not expect large retaliation from either the large or the other small firms.

3.2.2 Cooperating oligopolists and collusion

3.1.1.1 Cartels

Oligopolistic interdependence may lead to intense rivalry, but it can also result in collusion. Collusion occurs when the firms in an oligopoly realise that they can jointly increase their profit by raising the product's price and working out an agreement for dividing the market. When collusion is open, formal and involves all or most producers in the market, the result is called a cartel, which will be explained by using Figure 3.5.

Figure 3.5 Cartel demand function



Source: Lindsey, 1988:263

In the above figure, suppose the heads of 100 firms meet to form a cartel. They hope that by replacing competition with cooperation they can all benefit. They elect a cartel manager, who is asked to work out a production and marketing plan that will result in the maximum total profits for the industry and to divide it fairly among its members. The profit-maximising problem the cartel manager faces is exactly the same as that faced by a monopolist. Industry profits are highest at the output level at which MR = MC (200 000 units per month). If output is restricted to that quality, the price can be raised to $2 per unit, which will yield $200 000 per month of pure economic profit. To divide this profit among all cartel members, the manager will give each firm an output quota of 2 000 units a month, half as much as each produced before the cartel was formed. In this way, the member firms will reap the benefits of pure monopoly despite their small size and large numbers.

For consumers, cartels mean a smaller supply of goods and higher prices. Fortunately for consumers, cartels have some built-in problems that make them hard to form and unstable:

- The first problem from which cartels suffer is control over entry. Any industry that has prices above the level of long-run average cost tends to attract new firms.
- The second, and even more serious, inherent problem of cartels is enforcing output quotas. In a cartel, each member has an incentive to cheat by producing output beyond its quotas.

Formal cartels are not unknown, but they are rare. They are uncommon partly because of their inherent instability, and because they are also illegal under South Africa's competition act 89 for 1998. Nevertheless, imperfect cartels are still formed and are usually the result of an implicit agreement on production quotas amongst members. That factor plays a role in whether the firms in an oligopoly can, even without open collusion, tacitly co-ordinate their price and output decisions in a way that will jointly maximise their profit:

- Number and size of firms. Coordination is easier in a market with only two or three large firms. Coordination is also easier if there is one dominant firm.
- Nature of the product. A homogeneous product with a smooth flow of orders tends to make coordination easier.

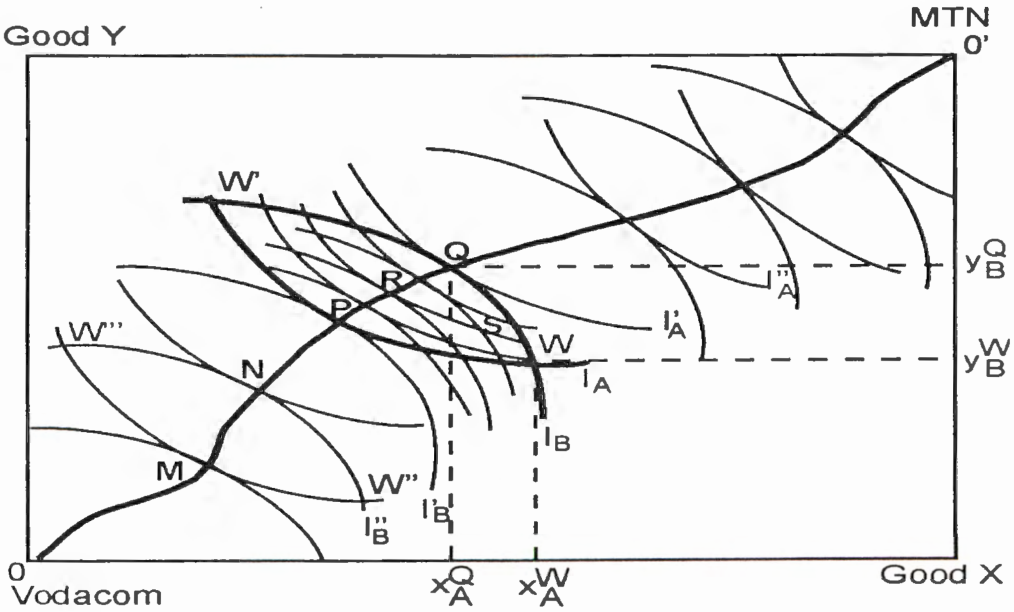
- Growth and innovation. In a market with rapidly changing elements, any agreement will soon be made obsolete by changing conditions or disrupted by the entrance of new buyers or sellers.
- Ease of entry and exit. Barriers to entry play an important role. Even if there are only a few firms in the market, the threat of entry by new firms may force existing ones to practice limit pricing to avoid attracting new rivals (Lindsey, 1988:263-268).

3.3 Economic welfare impact of South Africa's cellular ICT sector

Examining the social welfare of a market determines if that market is functioning at an optimum production point and if that point is the best optimum point in the market.

Consider Figure 3.6 where a simplified '2X2' pure exchange economy is represented by an Edgeworth Box.

Figure 3.6 Edgeworth Box

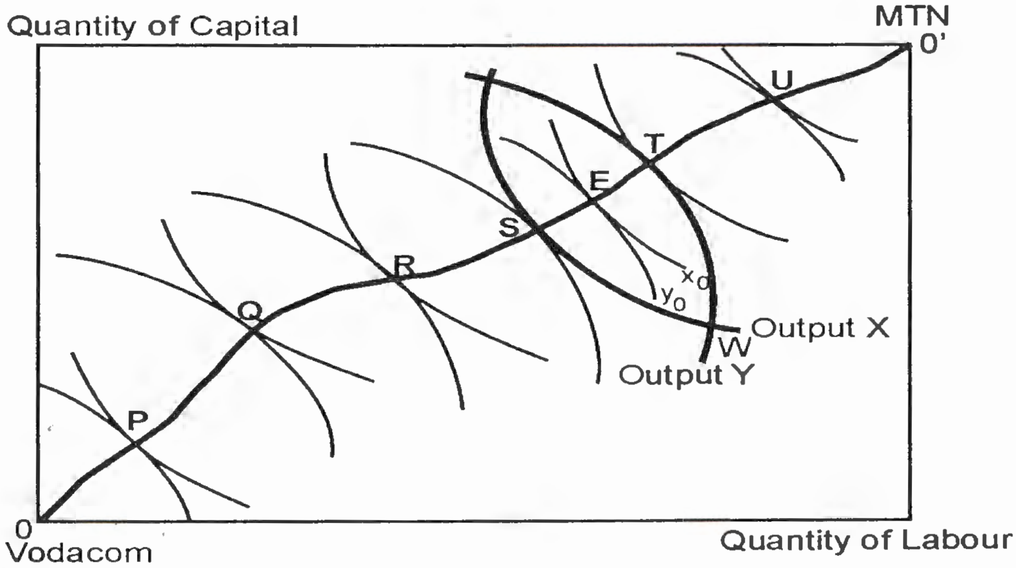


Source: Antoniou, 1993:227.

In the figure above the origins of Vodacom's indifference map is on the bottom left corner and that of MTN's at the top right. The allocations represented by the points of tangency of the two indifference maps, P an Q, depict net welfare improvement as these are feasible (Pareto-efficient) allocations that will not make at least one consumer better-off without making the other worse-off (Paretian rule). The set of allocations on the contact curve satisfying the Pareto-improvement criterion for a given initial endowment is called the 'core' of the economy. Therefore, Pareto-efficient allocations must be such that the MRS between the two commodities, MRS$_{XY,}$ is equal across consumers. The Pareto-efficiency criterion is only useful insofar as it allows us to assess changes in social welfare as a result of alternative allocations in and out of the core; the composition of the core depends, in turn, on the initial endowment of goods or the initial distribution of income (Antoniou, 1993:226-228).

It is possible to apply the Pareto-efficiency criterion to find the efficient allocation of inputs in an economy with a production sector. Consider Figure 3.7.

Figure 3.7 Production Edgeworth Box



Source: Antoniou, 1993:228.

In the above figure, also for a '2X2' economy, an allocation of resources off the contact curve OO', such as W, will not be Pareto-efficient. The Pareto-efficient allocation of resources must be on the contact curve, and requires that MRTS between inputs be equal across firms. Assuming that the economy allocates resources at point E and it produces a total quality of X equal to x_0, and Y equal to y_0. This corresponds to point ε on the production possibility frontier depicted in Figure X. The Pareto-efficiency criterion requires that these goods shall be allocated between the two consumers, according to allocation ε' where, $MRS_{XY} = MRT_{XY}$. Failure to satisfy this condition will mean that, in this economy, it is possible to change the combination of goods produced, in such a way as to improve one individual's welfare, while maintaining that of the other constant.

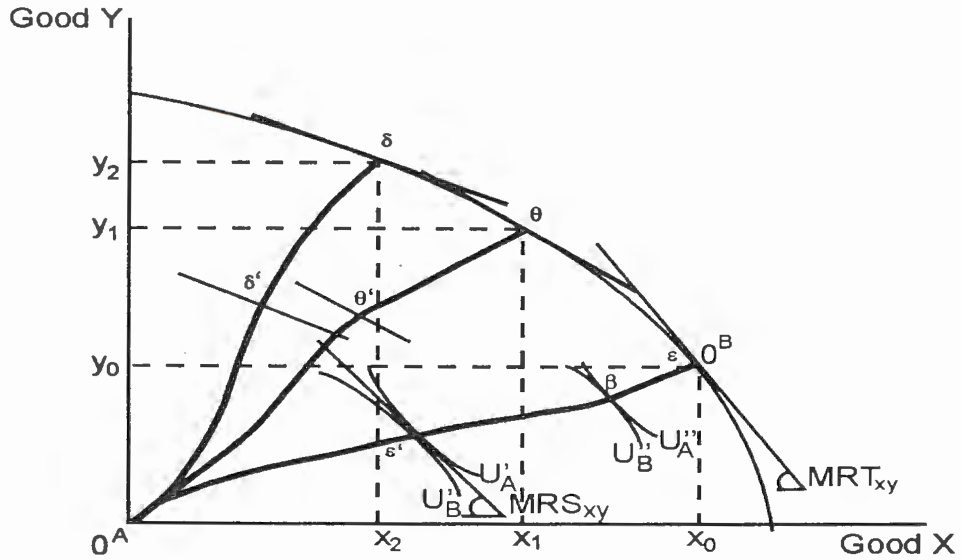
The two theorems of welfare economics can now be derived:

- That any allocation of resources realised in a set of markets, under conditions of competitive general equilibrium, will be Pareto-efficient (Antoniou, 1993:228). This theorem rests on the assumption that individuals have neither price-making nor market-making capacities (Makowski & Ostroy, 1995:808).

- Under certain conditions which are usually satisfied in a competitive economy, there will always be a set of relative market prices that can achieve every Pareto-efficient allocation in the core (Antoniou, 1993:232). According to Bryant (1994) the second fundamental theorem can be misinterpreted if the valid claim is replaced with the assertion that the market can achieve an arbitrary Pareto optimum.

Consider Figure 3.8, where the production possibility frontier (PPF) is depicted. The PPF is a tool that economists use to delineate the set of all possible production combinations of two goods, X and Y, using a given level of economic resources, with a given pool of technological know-how, and at a given moment in time.

Figure 3.8 Production possibility frontier

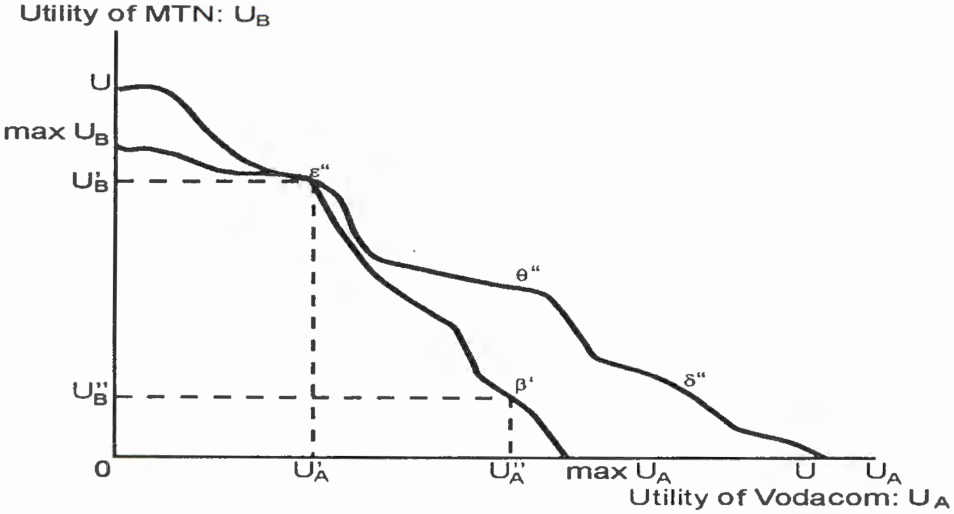


Source: Antoniou, 1993:230.

Inside Figure 3.8, alternative Edgeworth Boxes corresponds to different Pareto-efficient levels of production of the two goods X and Y is given. One such Edgeworth Box, whose dimension is given by, point ε on the PPF, that is x_0 by y_0. Within this box, there is a contact curve, O^AO^B, indicating alternative levels of utilities for Vodacom and MTN that could, potentially, satisfy the Pareto-efficiency criterion. These alternative Pareto-efficient levels of utilities can be depicted in the utility space in Figure X, which is called the utility possibility frontier (UPF), for that particular Edgeworth Box.

At point of origin O^A, where MTN has everything and Vodacom has nothing, the level of utility for MTN is the greatest, equal to maxU_B, while at the other end, O^B, Vodacom's utility is the greatest possible, maxU_A. These two levels are the intercepts of that particular UPF. Furthermore, utility combination ε'' corresponds to point ε', and β' to point β on the contact curve. Repeating this process for the entire contact curve, the UPT for that box is depicted. As stated earlier, only one of these allocations will be Pareto-efficient in both production and exchange, and that is ε' where the $MRT_{XY} = MRS_{XY}$. Consider Figure 3.9.

Figure 3.9 Utility possibility frontier



Source: Antoniou, 1993:230.

In Figure 3.9, if all the points representing the alternative levels of utility corresponding to all the Pareto-efficient allocations of resources, for alternative 'boxes', the 'grand' utility possibility frontier UU, is obtained. This frontier represents the highest levels of utility attainable by one consumer, given the level of the other. It serves as a utility constraint on society, separating the utility space in two: the combinations that are feasible, available and Pareto-efficient, also known as the utility possibilities set, from the rest. A movement along this frontier implies a different product mix, which in turn implies a different input usage and therefore a different distribution of income. The entire UU frontier may also shift up, down, or twist around a particular point, for two broad reasons: either as a result of changes to the underlying PPF, due to technological change, or the resource endowment of the economy, or following changes to the tastes of consumers (Antoniou, 1993:233-234).

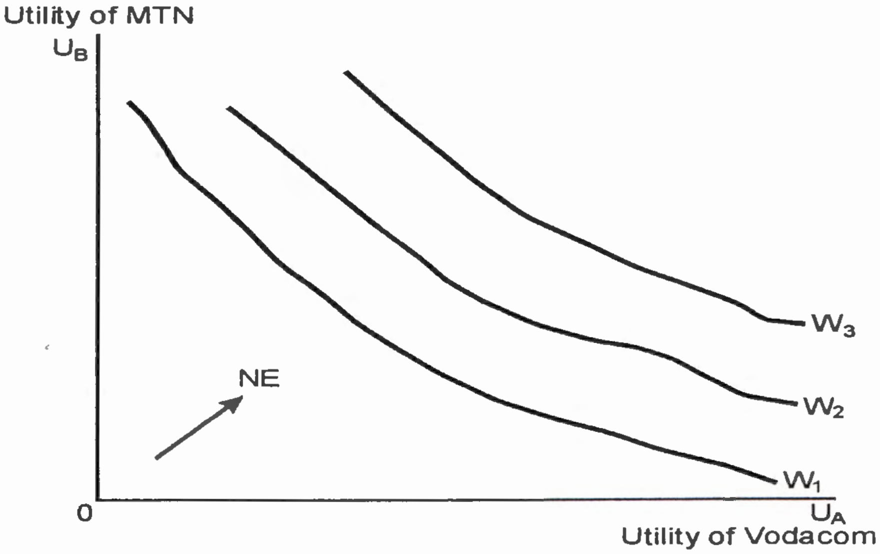
In the previous subsection a set of satisfaction levels were found. Among these alternative levels the most efficient point must be chosen. The Bergson-Samuelson function is used to choose the 'highest' point among the alternative levels on the grand utility possibility frontier UU, the highest point. One way of achieving this is to define some sort of 'utility function' for society as a whole. One such function is the Bergson-Samuelson-Graff welfare function. This function is based on an idea that was first proposed by Adam

Bergson and later developed by Paul Samuelson and J. de V Graff (Antoniou, 1993:235).

This function, sometimes called the W function, is based on a very simple idea, that is the 'ceteris paribus', its value must increase (decrease/stay constant) whenever the welfare of at least one individual member of society increases (decreases/stays constant). This means that the levels of utility of each member of society must be an argument of this function. Implicitly, this means that this is a Pareto-type social welfare function. Furthermore, it requires that the level of satisfaction of each member depends only on the consumption bundle open to him/her, that is, there are no externalities in consumption.

Under these conditions, it can be shown that the shape of the constituent indifference curves, as depicted in Figure 3.10 will determine the shape of W.

Figure 3.10 Social welfare functions

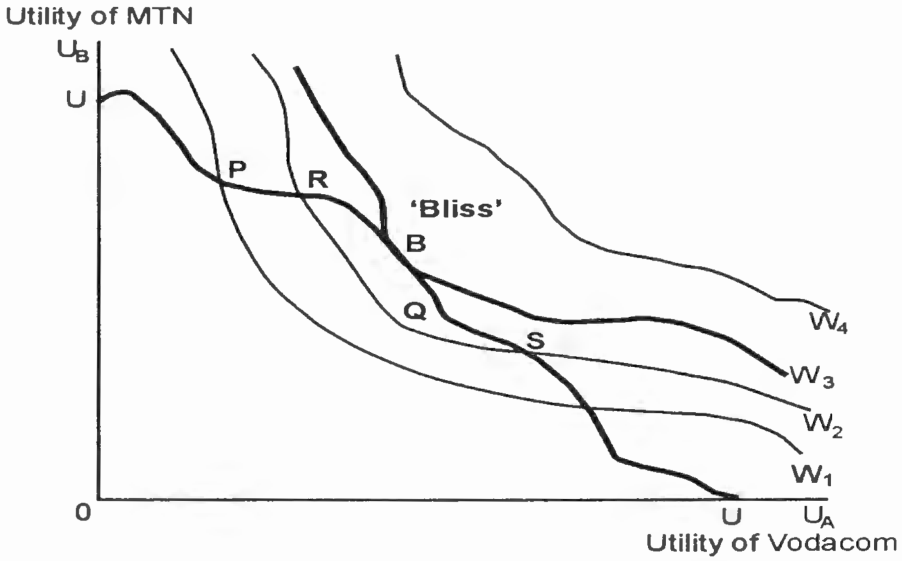


Source: Antoniou, 1993:236.

In Figure 3.10, Vodacom and MTN's, set of W social welfare functions are determined by the shape of their constituent indifference curves. These functions are convex to the origin and its value, and thus social welfare, will increase as one move in a North-East (NE) direction in the utility space. These various W functions will never intersect (Antoniou, 1993:235).

Consider Figure 3.11, where the grand utility possibility frontier UU, and these set of Bergson social welfare functions, W_1, W_2, W_3, W_4 are given.

Figure 3.11 Grand utility possibility frontier



Source: Antoniou, 1993:237.

In the above figure all the points on the UU frontier, such as P, R, S, or B, are Pareto-efficient while those inside the utility possibilities space, like Q are not. Clearly, from all these points on the UU curve, point B is socially preferable as it is situated on the highest Bergson social welfare function, and is known as the 'general optimum' or 'constrained bliss' point. This, 'constrained bliss' represents the only feasible Pareto-efficient level of social welfare over which it is not possible to improve (Antoniou, 1993:236).

Edlin & Emich (1999) found that the welfare losses from price-matching policies in the United States, are the highest in markets where fixed costs are low relative to marginal costs. In these markets price matching yields a large mark-up over the competitive price, which attracts a great deal of inefficient entry.

According to Justman (1996), the highest rate of investment in research and development (R&D) and the highest ratio of R&D to sales were found to occur in monopoly. However, the expected net present value of industry R&D outlays reached its highest levels in oligopolistic market structures with two or three firms.

Hamilton & Sandin (1997) demonstrated the importance of industry cost structure in determining the welfare implications of uniform policy in imperfect competitive markets. He found that a uniform tax policy could lead to a greater or lesser welfare change than expected when potential asymmetry is ignored in policy analysis.

3.4 The structure of the South Africa's cellular ICT sector

The reason why some markets are more concentrated than others are due to economies of scale. In any output range in which long-run average costs decreases as output increases, the firm is said to experience economies of scale (Lindsey, 1988:194). In market structures were there are high fixed costs, the cost per unit is initially high. A few players and sometimes only one player (monopoly) characterise these market structures.

Telecommunications is a technological intensive industry, which was traditionally viewed as a natural monopoly (Jehiel & Moldovanu, 2000:1). This is where there is high fixed (sunk) costs (approximately R 13bn for both MTN and Vodacom) and low marginal costs. In telecommunications there are fixed costs associated with establishing the network, lower costs in increasing the number of users connected to the network, and almost zero cost in increasing the number of calls made, subject to the capacity of the lines.

The nature of the telecommunications network dictates that economies of scale will arise as additional consumers subscribe to telephone services. In addition, the expansion of the network by one subscriber increases the utility of all incumbent subscribers marginally, since their opportunities for telecommunication have been increased. On a decentralized basis, in an environment with non-zero transaction costs, the positive externalities generated by an additional subscriber go unpriced and uncompensated. The supply-side manifestation of this market failure is the risk that service providers in a competitive environment will engage in "cream-skimming", or servicing only the lucrative markets. Areas that do not offer profit potential may not receive telecommunications service, although society as a whole benefits from higher penetration (Achterberg, 1999:4,10).

The impact of deregulation on returns to scale in telecommunication may be significant. Hsieh and Hsing (1994:104) found that the returns to scale rose by 5.7 (%) percent after deregulation. For robustness, Hsieh and Hsing also used a partial adjustment model. Their results showed that the impact of deregulation is significant and returns to scale rose by 4.8 percent. Thus, in creating a more competitive environment and providing consumers with more choices, scale economies in telecommunication as a whole have also increased.

Barriers to entry by new firms is one reason why an industry may be more concentrated than economies of scale alone would indicate. A barrier to entry may be defined as any factor that prevents a new firm from competing on an equal footing with existing firms. National, province or local governments may often create barriers deliberately to enter into oligopolistic industries. In such cases, the government stops short of creating a pure monopoly but still limits the number of firms to a figure below that which would exist under conditions of free entry (Lindsey, 1988:261-262). The sources of entry barriers are typically characterized as being either exogenous or endogenous. Exogenous entry barriers include those intrinsic economic or technical factors affecting an industry that is beyond the direct control of the firms operating in an industry, e.g. large capital requirements. In contrast endogenous barriers to entry are the direct result of actions taken by the incumbent firms, e.g. maintaining excess production capacity (Mathis & Koscianski, 1995:431).

The South African cellular ICT industry is an oligopoly, where the two firms control 60-100 percent of the market. But there are significant barriers to entry (Trebing, 1996:561):

- Inherent network economies that promote concentration and discretionary behaviour;

- Industry-specific barriers to entry (including long gestation periods, substantial sunk costs, and vertical integration);
- Common corporate control of differentiated markets of varying degree of demand elasticity that facilitate price discrimination, cross subsidisation and risk shifting; and
- Control of monopoly focal points (such as the local loop and the transmission grid).

3.4.1 Competition in South Africa's cellular ICT sector

As stated above the telecommunications industry is a technology intensive industry, where technology has a non-rival character (Cozzi, 1999:23). Changing a price may be a dangerous strategy for an oligopoly. If the firm lowers the price, its competitors are also likely to lower theirs, and then all will suffer from lower profits. According to Taylor (1998) on the other hand, raising prices may lead to loss of market share unless competitors also raise their prices. That is why oligopolistic firms compete, mainly through non-price variables, such as advertising their brandname (Basson, 1996:9).

Advertising is one of the most important non-price competition variables and also plays a major role in differentiation (De Fraja & Staderini, 1996:57). Advertising expenditure should be treated in the same way as investment in a durable good (Fershtman, 1984:271). Roberts and Samuelson (1988:215) found that advertising primarily affects the size of market demand and does not alter firm market shares. The market-share aspects of oligopolistic rivalry are better captured through changes in the number of brands sold by the firms, rather than by changes in advertising.

Advertising also generates externalities. Negative externalities occur when the firm's advertising gains sales of the firm at the expense of the rest of the industry. Alternatively, positive externalities may be realised because advertising by any single firm may increase that firm's sales while simultaneously increasing the rest of the industry's sales. Looking at South Africa's cellular ICT market, it has been claimed that the effect of advertising externalities of the one firm has leaded the other firm to advertise (Chen, 1993:29).

Freshtman (1984:280) determined that as the number of firms increased, the firms' goodwill and advertising expenditures at the equilibrium point tend to decrease. However, if one of the firms in this industry has a market share greater than one-half (Vodacom), this firm may increase its advertising when entry occurs.

3.5 Summary

In chapter two it was found that South Africa' current duopolistic market structure may change by the end of 2001 due to the entrance of a new cellular operator. This will result in an oligopolistic market structure. Depending on the equilibrium between these market participants, this long-awaited licensing may result in an improvement in quality, market penetration and services.

In this chapter South Africa's imperfect competition cellular ICT sector was examined. In section 3.2 imperfect competition was defined and examined through non-cooperating and cooperating models. Firstly, Cournot – and Stackelberg models were used to examine non-cooperating oligopolistic market structures. Here was found that the market output under a Cournot oligopoly lies between the competitive output and the monopoly output, and the Cournot output converges to the competitive output as the number of firms increase. In the Stackelberg model one of the firms may decide to take advantage of its relative size and adopt a different strategy than the one implied by Cournot. In this model firms are aware that its own level of output has an effect on the market price and therefore on the optimum level of output of its opponent. It is however not a fact that the Stackelberg leader will earn higher profit as the follower can expect to earn a higher profit than the leader for any finite conditional variance of the signal. The Stakelberg firms combined produce more than their monopoly or Cournot counterparts, at lower price, but less than the competitive level.

Cartelism was used to examine cooperating oligopolies, where collusion occurs when the firms in an oligopoly realise that they can jointly increase their profit by raising the product's price and working out an agreement for dividing the market. Formal cartels are illegal in South Africa, however imperfect cartels are still formed and are usually the result of an implicit agreement on production quotas amongst members.

Section 3.3 examined the economic welfare impact of South Africa's cellular ICT sector to determine if this market is functioning at an optimum production point and if that point is the best optimum point in the market.

Section 3.4 examined the structure of South Africa's cellular ICT sector. The reason why some markets are more concentrated than others is due to economies of scale. Telecommunications is a technological intensive industry, which was traditionally viewed as a natural monopoly, due to high sunken costs. South Africa's cellular ICT sector also has significant barriers to entry, preventing new firms from competing on an equal footing with the existing firms.

Competition in South Africa's cellular ICT sector is not price driven, as a change in price may be a dangerous strategy for an oligopoly. This is only one of the multitude of dynamic interactions in oligopolies that none of the examined oligopoly theories do justice to. It is not reasonable for one firm to assume that the other firm's behaviour will not be strategic. In fact, an oligopolist must spend a great deal of effort in forecasting his rivals' response to any action that it takes. One approach to this problem involves the use of game theory, which has the added virtue of reinforcing our understanding of oligopolist interdependence. This will be the approach in chapter four.

Chapter 4: Game theory and oligopolistic behaviour

4.1 Introduction

In the previous chapter it was determined that the traditional way of modelling oligopolistic behaviours does not adequately capture the multitude of dynamic interactions which could arise in an oligopolistic market setting (Robson, 1990:82). One approach to this problem involves the use of game theory, which has the advantage of modelling oligopolistic interdependence.

Game theory is used extensively by industrial organisations, and also in many other fields of economic theory like, labour market economics, political economics, environmental economics, and general macro-economics to model behaviour both in markets (imperfect competition, auctions, bilateral bargaining) and outside markets (policy co-ordination among different countries or groups, regulation, corruption, policy, choice, contracting) (Sloth, 2000).

In game theory, the equivalent to the Cournot equilibrium is known as the Nash equilibrium, whereby no player has an incentive to change his (optimum) strategy even after the choices of all the players are revealed. Clearly, if both players have dominant strategies then, by definition, the outcome will be Nash equilibrium (Antoniou, 1993:295). These Nash equilibria are not only Pareto optimal, but also coincide with the set of Walrasian equilibria (Maskin, 1999:23). This 'Law' states that in an N-goods economy, if the N – 1 markets are in equilibrium, where the excess demand equals zero in each one of them, then the Nth market must also be in equilibrium (Antoniou, 1993:207).

In this chapter the use of game theory in oligopolistic market structures will be examined. Firstly, section 4.2 will start by giving a description of game theory. In section 4.3 zero-sum game is examined through normal and extensive form. In section 4.4 nonzero-sum game is examined, using bimatrix games.

Thereafter the Stakelberg equilibrium solution will be examined. In section 4.6 models of entry deterrence are examined. Finally, section 4.7 concludes.

4.2 Description of game theory

Game theory is a branch of mathematical analysis developed to study decision making in conflict situations. Such a situation exists when two or more decision-makers who have different objectives act on the same system or share the same resources (Heylichen et al, 2000). Game theory provides a mathematical process for selecting an optimum strategy (an optimum decision or a sequence of decisions) in the face of an opponent who has a strategy of its own (Mcafee et al, 1996).

Game theory can be divided into two branches, cooperative and non-cooperative game theory. In non-cooperative game theory the unit of analysis is the individual participant in the game who is concerned with doing as well for himself as possible, subject to clearly defined rules and possibilities. In cooperative game theory the unit of analysis is most often the group (Kreps, 1993:9).

This study will only examine non-cooperative game theory. The reasons for this are - because players in oligopolistic market structures seldom approach the fully collusive outcome (Meister, 1999:383). If co-operative game exists, they can, in general, be reduced to optimal control problems by determining a single cost function to be optimised by all players, which also suppresses the "game" aspects of the problem (Basar & Olsdor, 1982:5).

4.3 Zero-sum games

A zero-sum game is a game in which the sum of the payoffs of all the players are zero whatever strategies they choose (Rasmusen, 1989:32).

4.3.1 Normal form zero-sum games

The most elementary type of two-person zero-sum games is matrix games. There are two players, to be referred to as Vodacom (P1) having m strategies and MTN (P2) having n strategies, which can be represented by an (m x n) array of numbers, giving the payoffs from Vodacom to MTN for each of the m□n possible outcomes. Such an array is called an (m x n) dimensional matrix A = {a_{ij}} (Straffin, 1993:7). Each entry of this matrix is an outcome of the game, corresponding to a particular pair of decisions made by the players. For Vodacom, the alternatives are the m rows of the matrix, while for MTN the possible choices are the n columns of the same matrix. These alternatives are known as the strategies of the players. In general, a player's strategy can be price, quantity, advertising, capacity, or any other variable under the firm's control (Slade, 1995:371). If Vodacom chooses the ith row and MTN the jth column, then a_{ij} is the outcome of the game, and Vodacom pays this amount to MTN. In case a_{ij} is negative, this should be interpreted as MTN paying Vodacom the positive amount corresponding to this entry.

In a more general framework, these outcomes represent utility transfers from one player to the other. Each element of the matrix A can be viewed as the net change in the utility of Vodacom. Then, regarded as a rational decision-maker, Vodacom will seek to minimize the outcome of the game, while MTN will seek to maximize it, by independent decisions.

Assuming that this game is to be played only once, then a reasonable mode of play for Vodacom is to ensure its losses against any behavior of MTN. Under such an incentive, Vodacom is forced to pick that row (I^*) of matrix A, whose largest entry is no bigger than the largest entry of any other row. Hence, if Vodacom adopts the i^*th row as its strategy, where I* satisfies the inequalities then its losses will be no greater than the loss ceiling of Vodacom, or equivalently, the security level for its losses. The security level for his losses can be defined as:

$$\overline{V}(A) \,\underline{\underline{\square}}\, \max_j a_{i^*j} \leq \max_j a_{ij}, \quad i = 1, \ldots, m, \ldots\ldots\ldots\ldots 1$$

Where strategy "row i^*" that yields this security level will be called a security strategy for Vodacom. Adopting a similar mode of play, MTN will want to secure its gains against any behavior from Vodacom, and consequently, it will choose that column (j*) whose smallest entry is no smaller than the smallest entry of any other column. By deciding on the j*th column as its strategy, MTN secures its gains at the level $\underline{V}$ which can be termed the gain-floor of MTN, or equivalently, the security level of his gains.

$$\underline{V}(A) \; \underline{\underline{\square}} \; \min_{j} a_{i^*j} \geq \min_{j} a_{ij}, \quad i = 1, \ldots, m, \ldots\ldots\ldots\ldots\ldots\ldots 2$$

Furthermore, any strategy for MTN that secures his gain floor, such as "column j*", is called a security strategy for MTN.

In every matrix game $A = \{a_{ij}\}$,

- The security level of each player is unique;
- There exists at least one security strategy for each player; and
- The security level of Vodacom (the minimizer) never falls below the security (Basar & Olsdor, 1982:19-21).

To illustrate, these facets of matrix games, consider the following (3 x 4) matrix:

Table 4.1 Normal form zero-sum game

		MTN		
	1	3	3	-2
Vodacom	0	-1	2	1
	-2	2	0	1

In table 4.1 MTN (maximizer) has a unique security strategy, "column 3" (i.e. $j^* = 3$), securing it a gain-floor of $\underline{V} = 0$. Vodacom (minimizer), on the other hand, has two security strategy, "row 2" and "row 3" (i.e. $i_1^* = 2$, $i_2^* = 3$), yielding it a loss ceiling of $\overline{V}$ = $\max_j a_{3j}$ = 2 which is above the security level of MTN. Now, if MTN plays first, then it chooses its security strategy "column 3", with Vodacom's unique response being "row 3", resulting in an outcome of 0 = $\underline{V}$. If Vodacom plays first, it is actually indifferent between its two security strategies. In case it chooses "row 2", then MTN's unique response is "column 3", whereas if it chooses "row 3", MTN's response is "column 2", both pairs of strategies yielding an outcome of 2 = $\overline{V}$. Consider table 4.2, where the players arrive at their decisions independently.

Table 4.2 Independent decision making

	MTN	
Vodacom	3	1
	-1	1

In Table 4.2, "row 2" and "column 2" are the security strategies of Vodacom and MTN, respectively, resulting in the same security level $\overline{V}$ = $\underline{V}$ = 1. These security strategies are in equilibrium, since each one is optimal against the other. Furthermore, since the security levels of the players coincide, it does not make a difference, as far as the outcome of the game is concerned. The strategy pair {row2, column 2}, possessing all these favorable features is the only option that could be considered as the equilibrium solution of the matrix game (Basar & Olsdor, 1982:22-23). Such equilibrium strategies are known as saddle-point strategies, and the matrix game, is said to have a saddle point in pure strategies, mapping each player's possible information sets to one action (Rasmusen, 1989:69).

4.3.1.1 Uncertain strategies

In matrix games in which players act independently but do not posses a saddle point, neither player would want to play a single strategy with certainty, for the other player could take advantage of such a choice (Straffin, 1993:13). A solution to this problem is to enlarge the strategy spaces, so as to allow the players to base their decisions on the outcome of random events – thus leading to so-called mixed strategies. A mixed strategy for a player is a probability distribution on the set of his pure strategies (Ishiishi, 1983:57).

Consider the matrix game A = $\{a_{ij}\}$ with m rows and n columns. In this game, the “strategy space” of Vodacom comprises m elements, since it is allowed to choose one of the m rows of A. If Γ^1 denotes this space of (pure) strategies, then Γ^1 = {row 1, . . ., row m}. An allowable strategy for Vodacom is to choose “row 1” with probability y_1, “row 2” with probability y_2, . . . , “row m” with probability y_m, where $y_1 + y_2 + . . . + y_m = 1$. The mixed strategy space of Vodacom (Y), is comprised of all such probability distributions. Since the probability distributions are discrete, Y simply becomes the space of all nonnegative numbers y_i that add up to 1, which is a simplex (Basar & Olsdor, 1982:25).

4.3.1.2 Dominating strategies

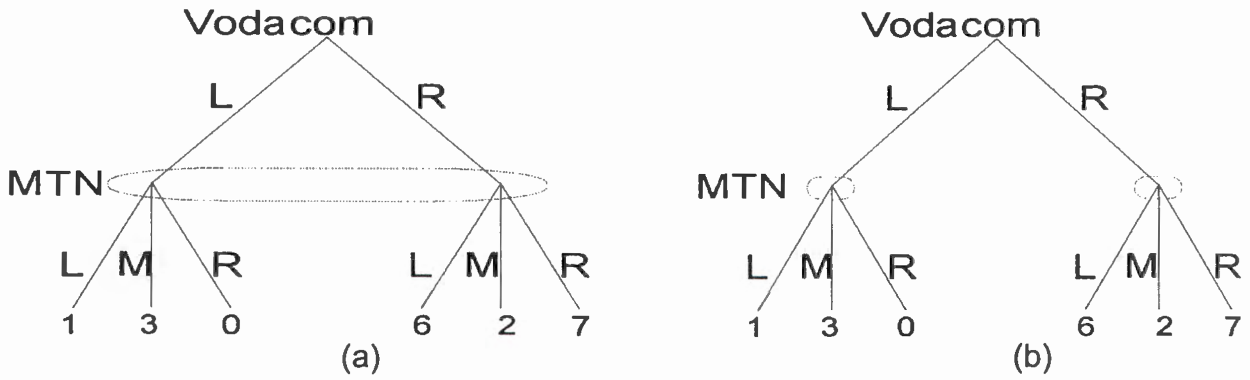
Given an (m x n) matrix game A = $\{a_{ij}\}$, “row i” dominates “row k” if $a_{ij} \leq a_{kj}$, j = 1, ..., n, and if, for at least one j, the strict inequality-sign holds. In terms of pure strategies (a strategy which maps a player’s possible information set to one action), this means that the choice of the dominating strategy, i.e. “row i” is at least as good as the choice of the dominating strategy, i.e. “row k” and at least one outcome in “row j” i for all j = 1, ..., n, then that “row i” strictly dominates “row k”, in which case, regardless of what MTN chooses, Vodacom does better with “row i” than with “row k” (Basar & Olsdor, 1982:38). It therefore follows that Vodacom can dispense strictly dominating strategies and consider only strictly undominated ones, since adoption of a strictly dominated strategy is apt to increase the security level of Vodacom.

4.3.2 Extensive form zero-sum games

4.3.2.1 Single-act games

Some important issues like the order of play in the decision process, information available to the players at the time of their decisions, and the evolution of the game in the case of dynamic situations are suppressed in the matrix description of a zero-sum game. An alternative to the normal form, which explicitly displays the dynamic character of the problem, is known as the extensive form of a two-person zero-sum game. An extensive form involves a tree structure with several nodes and branches, providing explicit description of the order of play and the information available to each player at the time of his decision(s); and the game evolves from the top of the tree to the tip of one of its branches (Rasmusen, 1989:45). Two such tree structures are depicted in Figures 4.1 and 4.2.

Figure 4.1 Single-act zero-sum extensive form games



Source: Basar & Olsder, 1982:40.

In the figures above are two zero-sum games in extensive form, differing only in the information available to MTN. In both figures, Vodacom has two alternatives (branches) to choose from, whereas MTN has three alternatives, and the order of play is such that Vodacom act before MTN does. The numbers at the end of the lower branches represent the pay-offs to MTN if the players select the corresponding paths.

It should be noted that the two zero-sum games displayed in Figure 4.1 are equivalent in every aspect other than the information available to MTN at the time of his play, which is indicated on the tree diagrams by dotted lines enclosing an area (information set) including the relevant nodes. In Fig. 4.1 (a), the two possible nodes of MTN are included in the same dotted area, implying that, even though Vodacom acts before MTN does, MTN does not have access to his opponent's decisions. This is, of course, equivalent to the case when both players act simultaneously (Basar & Olsdor, 1982:39-40).

Fig. 4.1 (b), however, admits a different matrix game as its normal form and induces a different behavior on the players. In this case, each node of MTN is included in a separate information set, thus implying that MTN has perfect information as to which branch of the tree Vodacom has chosen. If u^1 denotes the actual choice of Vodacom and $y^2(u^1)$ denotes a strategy for MTN, as a maximiser MTN's optimal choice will be

$$\gamma^{2*}(u^1) = \begin{cases} M & \text{if } u^1 = L \\ R & \text{if } u^1 = R. \end{cases}$$

Not knowing this situation ahead of time Vodacom adopts the strategy

$$\gamma^{1*} \equiv u^{1*} = L$$

With the equilibrium outcome of the game being 3, which is also the upper value of the matrix game (Basar & Olsdor, 1982:41).

4.3.2.1.1 Transforming extensive form into normal form games

To obtain the same saddle-point solution by transforming the extensive form into an equivalent normal form, all the possible strategies of the players must be delineated. For Vodacom, there are two possibilities:

$$\gamma^1 = L \text{ and } \gamma^1 = R.$$

For MTN there exist $3^2 = 9$ possible strategies, which are $\gamma_1^2(u^1) = u^1$, $\gamma_2^2(u^1) = L$, $\gamma_3^2(u^1) = M$, $\gamma_4^2(u^1) = R$,

$$\gamma_5^2(u^1) = \begin{cases} L, & \text{if } u^1 = L \\ M & \text{if } u^1 = R. \end{cases}$$

.

.

.

$$\gamma_9^2(u^1) = \begin{cases} L, \text{ if } u^1 = L \\ M \text{ if } u^1 = R. \end{cases}$$

Where the subscripts I = 1,…,9 denote a particular ordening of the possible strategies of MTN.

Table 4.3 Transformation into a normal form game

MTN

Vodacom	1	1	3	0	1	0	3**	3*	0	L
	0	6	2	7	2	6	7	6	2	R
	1	2	3	4	5	6	7	8	9	

The equivalent normal form of the zero-sum game of figure 4.1 is the 2 x 9 matrix game which admits two saddle points, as indicated, with the dominant one being {L, column 7}. It is the same dominant saddle-point solution that corresponds to the one in Fig 4.1(b) (Basar & Olsdor, 1982:41-42).

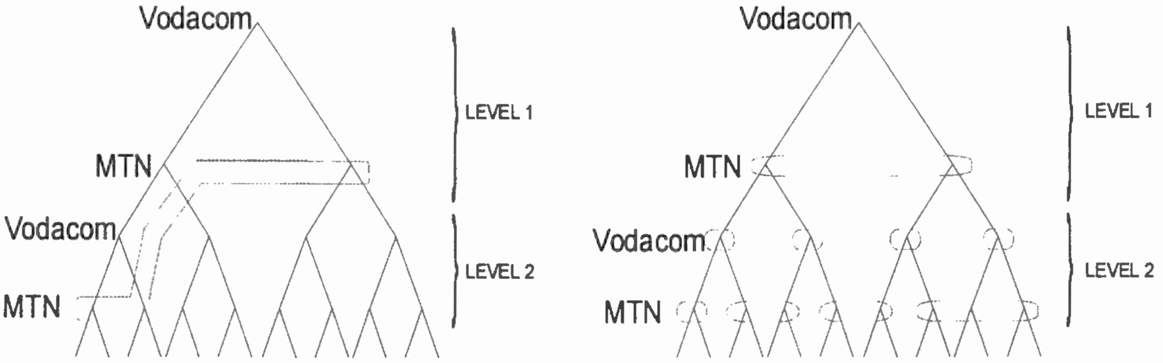
4.3.2.2 Multi-act games

In games in which players move more than once, their moves depend on information about the previous history of play. These games are called dynamic games (Cave, 1987:596). Zero-sum games in which at least one player is allowed to act more than once, and with possibly different information sets at each level of play, are known as multi-act zero-sum games. A multi-act two-person zero-sum game in extensive form is called a two-person zero-sum feedback game in extensive form, if:

- At the time of his act, each player has perfect information concerning the current level of play; and

- Information sets of the first-acting player at every level of play are singletons, and the information sets of the second-acting player at every level of play are such that none of them includes nodes corresponding to branches emanating from two or more different information sets of the other player.

Figure 4.2 Multi-act zero-sum extensive form games



Source: Basar & Olsder, 1982:51.

Figure 4.2 displays a zero-sum feedback game in extensive form. This is because Vodacom and MTN each have perfect information concerning the current level of play.

The appealing feature of feedback saddle-point solution is that it can be computed recursively, by solving a number of static games at each level of play. These feedback strategies are rules for choosing controls as functions of the current state (Slade, 1994:54). A zero-sum multi-act game does not necessarily admit saddle-point equilibrium in behavioural strategies, unless it is a feedback game (Basar & Olsdor, 1982:50-59). Games in which the players do not acquire any dynamic information throughout the decision process, and when they only know the level of play that corresponds to their action, are known as open-loop games (Slade, 1994:54).

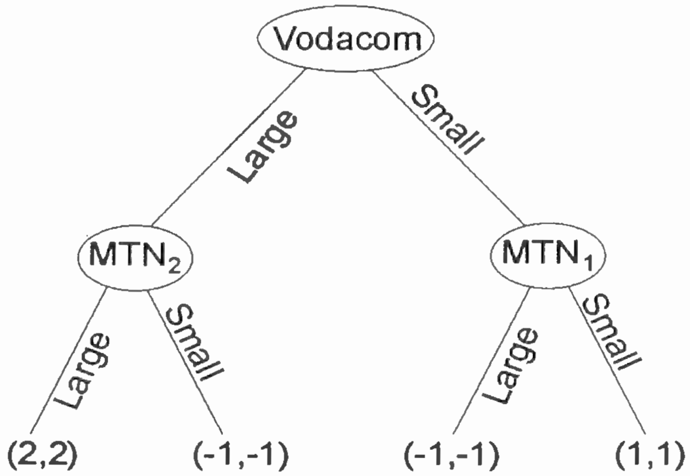
4.3.2.3 Prior and delayed commitment models

Since there is no extra information available to the players throughout the duration of an open-loop game, the players can decide on their actions at the beginning, and then there is no incentive for them to change these decisions during the actual play of the game. Such games in which decisions are made at the very beginning, and with no incentive to deviate from them later, are known as "prior commitment" games. Mixed saddle-point strategies can then be considered to constitute a reasonable equilibrium solution within such a framework. Feedback games, on the other hand, are of "delayed commitment" type, since each player could wait until he finds out what information set he really is, and only then announce his action (Basar & Olsdor, 1982:59).

4.3.2.4 Perfect equilibrium points

In game where each player has more than one move, some unsatisfactory equilibrium points can be interpreted as utilising threats that are not credible. To avoid such equilibria, Selten (1975) proposed a refinement of the Nash equilibrium called the perfect equilibrium. Where perfect equilibrium can be defined as being subgame perfect. A combination of strategies is subgame perfect Nash equilibrium if it is a Nash equilibrium for the game and the relevant strategies are Nash equilibrium for every subgame (Karp, 1993:448). Consider Figure 4.3.

Figure 4.3 Perfect equilibrium point



Source: Rasmusen,1992:84.

In figure 4.3 there are three subgames: the entire game, the subgame starting at MTN_1 and the subgame starting at MTN_2. Now consider the following strategy combinations:

Equilibrium	Strategies	Outcome
X	{Large, (Large, Large)}	Both pick Large
Y	{Large, (Large, Small)}	Both pick Large
Z	{Small, (Small, Small)}	Both pick Small

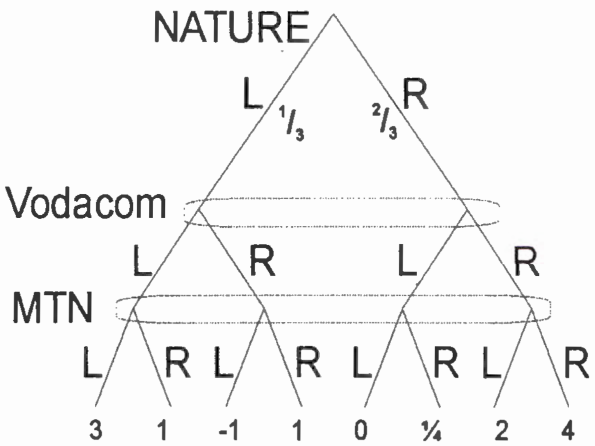
Recall that a subgame is a game consisting of a node which is a singleton in every player's information partition, that node's successors, and the payoffs at the associated end nodes. A strategy combination is a subgame perfect Nash equilibrium if it is a Nash equilibrium for the entire game and if its relevant action rules are a Nash equilibrium for every subgame.

This means that strategy combination X is not a subgame perfect equilibrium, because it is only Nash in the entire game and MTN_2 Strategy combination Z is not a subgame perfect equilibrium, because it is only Nash in the entire game and in MTN_2. But strategy combination Y is Nash in all three subgames. Perfectness is a way to eliminate of the weak Nash equilibria (Rasmusen,1992:84-85).

4.3.2.5 Zero-sum games with chance moves

In zero-sum games with chance moves, the final outcome is determined not only by the decisions of the two players, but also by the outcome of a chance mechanism whose odds between different alternatives are known a proiri by both players. This can be viewed as a three-player game wherein the third player, commonly known as "nature", has a fixed mixed strategy, as displayed in Figure 4.4 (Basar & Olsdor, 1982:59).

Figure 4.4 Zero-sum games with chance move



Source: Balsar & Olsder, 1982:61.

Figure 4.4 displays a zero-sum single-act game in extensive form that incorporates a chance move (nature). Here nature is a non-player who takes random actions at specified points in the game with specified probabilities (L = 1/3 and R = 2/3). MTN or Vodacom's payoff or loss depends thus on nature. For example a payoff's chance if Vodacom chooses L and MTN chooses R is, (1/3)(1) + (2/3)(1/4) = ½. This is less than the average equilibrium value of the zero-sum game. The increase in information with regard to the action of nature helps Vodacom to reduce its average losses, but works against MTN.

4.4 Nonzero-sum games

Bimatrix games will first be examined, as these games carry most of the silent features and intricacies of non-cooperative decision making.

4.4.1 Bimatrix games

A bimatrix game can be considered as a natural extension of the matrix game to cover situations in which the outcome of a decision process does not necessarily dictate the verdict that what one player gains the other one has to lose. Accordingly, a bimatrix game is comprised of two (m x n)- dimensional matrices, A = {a_{ij}} and B = {b_{ij}}, with each pair of entries (a_{ij}, b_{ij}) denoting the outcome of the game corresponding to a particular pair of decisions made by the players strategies. The alternatives available to the players are called their strategies. If Vodacom adopts the strategy "row I" and MTN adopts the strategy "column j", then a_{ij} (respectively, b_{ij}) denotes the loss incurred to Vodacom (respectively, MTN). Being a rational decision-maker, each player will strive for an outcome, which provides him with the lowest possible loss. Defining a non-co-operative equilibrium solution to bimatrix games, the basic property of a saddle-point equilibrium solution in zero-sum games, also finds relevance in nonzero-sum games. Consider the following (2 x 2) bimatrix game:

Table 4.4 Bimatrix normal form game

$$A = \begin{array}{|c|c|} \multicolumn{2}{c}{\text{MTN}} \\ \hline 1^* & 0 \\ \hline 2 & -1^{**} \\ \hline \end{array} \ \textbf{Vodacom,} \qquad B = \begin{array}{|c|c|} \multicolumn{2}{c}{\text{MTN}} \\ \hline 2^* & 3 \\ \hline 1 & 0^{**} \\ \hline \end{array} \ \textbf{Vodacom.}$$

In Table 4.3, a pair of strategies {row i*, column j*} is said to constitute to a non-cooperative Nash equilibrium solution to a bimatrix game ($A = \{a_{ij}\}$, $B = \{b_{ij}\}$) if the following pair of inequalities is satisfied for all i = 1, ..., m and j = 1, , n:

$$a_{i*j*} \leq a_{ij*} \text{ and } b_{i*j*} \leq b_{ij.}$$

The pair (a_{i^*j}, $b_{i^*j^*}$) is known as a non-cooperative Nash equilibrium outcome of the bimatrix game. Thus, Table 4.3, admits two Nash equilibria, as indicated: {row 1, column 1} and {row 2, column 2}. The corresponding equilibrium outcomes are (1, 2) and (-1, 0). This means that a bimatrix game can admit more than one Nash equilibrium solution, with the equilibrium outcomes being different in each case.

Only one of the two Nash equilibrium solutions is admissible ({row 2, column 2}), since it provides uniformly lower costs for both players. This pair of strategies can therefore be declared as the most "reasonable" non-cooperative equilibrium solution of the bimatrix game.

However, if a bimatrix game admits more than one admissible Nash equilibrium solution, then the equilibrium outcome of the game becomes rather ill defined – mainly due to the fact that multiple Nash equilibria are in general not interchangeable. This ambiguity disappears, whenever the equilibrium strategies are interchangeable, which necessarily requires the corresponding outcome to be the same (Basar & Olsdor, 1982:71-76).

4.4.1.1 Non-interchangeable Nash equilibria

A property of saddle-point strategies in zero-sum games is that they are also the security strategies of the players. In bimatrix games, one can still introduce security strategies for the players in the same way as it was done for matrix games. In a bimatrix game (A, B), the security strategies of Vodacom involve only the entries of matrix A, while the security strategies of MTN involve only those of matrix B.

There exists bimatrix games in which the security strategies do not correspond to any one of the equilibrium solutions, or bimatrix games in which they coincide with an admissible Nash solution. As an illustration of the latter possibility, consider Table 4.4.

Table 4.5 Prisoners dilemma game

MTN

$$\textbf{4.5} \quad A = \begin{array}{|c|c|}\hline 8^* & 0 \\ \hline 30 & 2 \\ \hline \end{array} \ \textbf{Vodacom,} \qquad \textbf{4.6} \quad B = \begin{array}{|c|c|}\hline 8^* & 30 \\ \hline 0 & 2 \\ \hline \end{array} \ \textbf{Vodacom.}$$

In Table 4.4, the bimatrix game has a unique pair of Nash equilibrium strategies, as indicated, which are also the security strategies of the players. Moreover, the equilibrium outcome is determined by the security levels of the players (Basar & Olsdor, 1982:76-77).

The preceding bimatrix game is known as the Prisoners' dilemma, where two criminals, suspected of having committed a serious crime, are detained before a trail. Since there are no direct evidence against them, their conviction depends on whether they confess or not. This general sort of situation arises in many contexts in economics (Hayes & Sophister, 1995). The unique Nash equilibrium in this case dictates that they both should confess. However a better solution for both, which is that they both should refuse to confess; but such a solution would require a cooperation of some kind. This solution is also not a Nash equilibrium, making it extremely unstable, since each player will find it to his advantage to unilaterally deviate from this position at the last minute.

Even if the security strategies might not be in non-cooperative equilibrium, they can still be employed in an actual game, especially in cases when there exists two or more non-interchangeable Nash equilibria or when a player is not completely sure of the cost matrix, or even the rationality, of the other player. Duopoly games, whether in prices or in qualities, are affected by a prisoners' dilemma, since for every firm the non-cooperative strategy dominates the cooperative one (Lambertini, 1997:184).

4.6.1.1 No Nash equilibrium strategies

In bimatrix games, where Nash equilibrium strategies does not exist. A pair $\{y^* \in Y, z^* \in Z\}$ constitute to a non-cooperative Nash equilibrium solution to a bimatrix game (A, B) in mixed strategies, if the following inequalities are satisfied for all $y \in Y$ and $z \in Z$:

$$y^{*\prime}Az^* \leq y'Az^*, \; y \in Y$$

$$y^{*\prime}Bz^* \leq y'Bz^*, \; z \in Z.$$

The pair $(y^{*\prime}Az^*, y^{*\prime}Bz^*)$ is known as a non-cooperative Nash equilibrium outcome of the bimatrix game in mixed strategies. And every game has at least one Nash equilibrium solution in mixed strategies (Basar &Olsdor, 1982:78).

4.6.2 N-person games in normal form

The class of N-person nonzero-sum finite static games in normal form model a decision making process similar in nature to that modeled by bimatrix games, but this time with N (>2) interacting decision makers (players).

Decisions are again made independently and out of a finite set of alternatives for each player. Since there exists more than two players, a matrix formulation on the plane is not possible for such games, thus making the display of possible outcomes and visualization of equilibrium strategies rather difficult. However, a precise formulation is still possible:

An N-person finite static game in normal form can be formulated as:

- There are N players t be denoted by P1, P2,...,PN, for the index set {1, 2, ...,N} by N;
- There are a finite number of alternatives for each player to choose from. Let m_i denote the number of alternatives available t Pi, and further denote the index set {1, 2, ... ,m_i} by M_i, with a typical element of M_i designated as $n_{i;}$
- If Pj chooses a strategy $n_j \in M_j$, and this so for all $j \in N$, then the loss incurred to Pi is a single number $a^i_{n1,\ldots,nN}$. The ordered N-tuple of all these numbers (over $i \in N$), constitutes the corresponding unique outcome of the game; and
- Players make their decisions independently and each one seeks unilaterally the minimum possible loss, of course by also taking the possible rational choices of the other players into account.

There is no simple method to determine the Nash equilibrium solutions of N-person finite games in normal form. One has to check exhaustively all possible combinations of N-tuples of strategies, to see which ones provide Nash equilibrium. This enumeration, though straightforward, could at times be rather strenuous, especially when N and/or $m_{i,}$ $i \in N$ are large. However, given an N-tuple of strategies asserted to be in Nash equilibrium, it is relatively simpler to verify their equilibrium property, since one then has to check only unilateral deviations from the given equilibrium solution. Consider the following 3-person game in which each player has two alternatives to choose from. That is N = 3 and $m_1 = m_2 = m_3 = 2$. With player one being Vodacom, player two MTN and player three the new cellular network provider (say Cell X). To complete the description of the game, the 2^3 = 8 possible outcomes are given as:

$$(a_1^1,1,1, a_1^2,1,1, a_1^3,1,1) = (1,-1,0)$$
$$(a_1^1,2,1, a_1^2,2,1, a_1^3,2,1) = (2,1,1)$$
$$(a_2^1,1,1, a_2^2,1,1, a_2^3,1,1) = (2,0,1)$$
$$(a_2^1,2,1, a_2^2,1,1, a_2^3,1,1) = (0,-2,1)$$
$$(a_1^1,1,2, a_1^2,1,2, a_1^3,1,2) = (1,1,1)$$
$$(a_1^1,2,2, a_1^2,2,2, a_1^3,2,2) = (0,1,0)$$
$$(a_2^1,1,2, a_2^2,1,2, a_2^3,1,2) = (0,1,2)$$
$$(a_2^1,2,2, a_2^2,2,2, a_2^3,2,2) = (-1,2,0).$$

These possible outcomes can then be displayed in the form of two (2 x 2) matrices

	MTN		
$N_3 = 1$:	(1,-1,0)*	(2,1,1)	**Vodacom**
	(2,0,1)	(0,-2,1)	

	MTN		
$N_3 = 2$:	(1,1,1)	(0,1,0)	**Vodacom**
	(0,1,2)	(-1,2,0)	

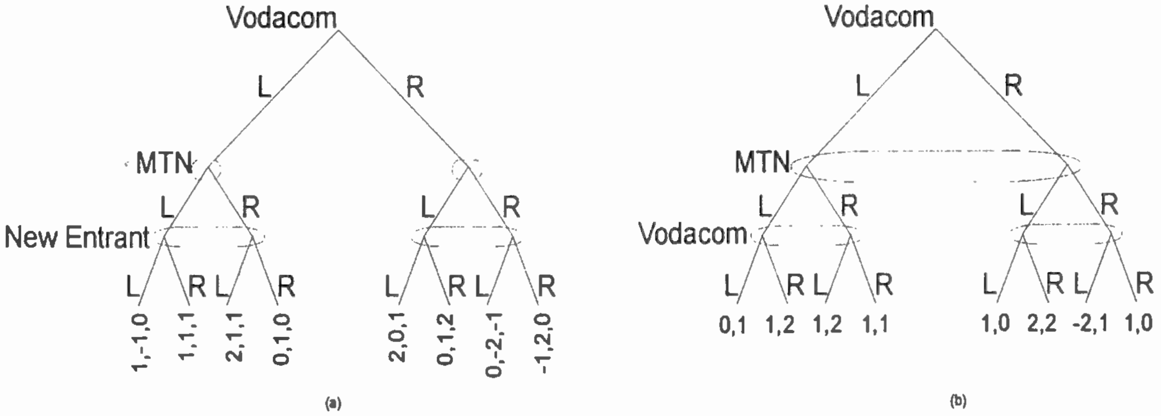
Here the entries of the left-handed matrix corresponds to the possible outcomes if Cell X's strategy is fixed at n_3 = 1, and the right-handed matrix provides possible outcomes if the entrant's strategy is fixed at n_3 = 2. The entry mark in the left-handed matrix is a Nash equilibrium outcome for this game. A verification of this assertion would involve three separate checks, concerning unilateral deviation of each player. If Vodacom deviates from this asserted equilibrium strategy n_1 = 1, then his loss becomes 1 which is not favourable. If MTN deviates from n_2 = 1, its loss becomes 1 which is not favourable either. Finally, if Cell X deviates from n_3 = 1, its loss becomes 1 which is higher than this asserted equilibrium loss 0. Consequently, the first entry of the left-handed matrix (1, -1,0), provides a Nash equilibrium outcome, with the corresponding equilibrium strategies being $\{n_1^* = 1,\ n_2^* = 1,\ n_3^* = 1\}$ (Basar &Olsdor, 1982:82-85).

4.6.3 N-person games in extensive form

A point in n-dimensional space is represented by an ordered n-tuple of real numbers, and is called an n-dimensional vector (Johnson, et.al,1993:530). The extensive form of an N-person nonzero-sum finite game without chance moves is a tree structure with:

- A specific vertex indicating the starting point of the game;
- N cost functions, each one assigning a real number to each terminal vertex of the tree, where the ith cost function determines the loss to be incurred to Pi;
- a partition of the nodes of the tree into N player sets; and
- a sub-partition of each player set into information sets $\{\eta_j^i\}$, such that the same number of immediate branches emanate from every node belonging to the same information set and no node follows another node in the same information set.

Figure 4.5 N-person nonzero-sum games in extensive form



Source: Balar & Olsder, 1982:93.

In Figure 4.5, two nonzero-sum finite games in extensive form are depicted. Figure 4.5 (a) represents a three-player single-act game in which the information sets of the players are such that both MTN and the new entrant

(Cell X) have access to the action of Vodacom. In an extensive form of a single-act game, with a fixed order of play, a player Pi is said to be a precedent of another player Pj if the former is situated closer to the vertex of the tree than the ladder. The extensive form is nested if each player has access to the information acquired by all his precedents. Furthermore, if the only difference between the information available to a player (Pi) and his closest precedent (say Pi – 1) involves only the actions of Pi – 1, and only at those nodes corresponding to the branches of the tree emanating from singleton information sets of P1 – 1, and this for all players, the extensive form is ladder-nested. In every single-act N-person game, which has a ladder-nested extensive form comprising a finite number of branches, there exists at least one Nash equilibrium solution in behavioural strategies (Basar & Olsdor, 1982:95-114).

Figure 4.5 (b), represents a two-player multi-act nonzero-sum finite game, in which Vodacom acts twice and MTN only once. In both extensive forms the set of alternatives for each player is the same at all information sets and it consists of two elements. The outcome corresponding to each possible path is denoted by an ordered N-tuple of numbers (a^1, ..., a^n), where N stands for the number of players and a^i stands for the corresponding costs to Pi (Basar &Olsdor, 1982:92-93). Furthermore a multi-act N-person nonzero-sum game in extensive form with a fixed order of play is called an N-person nonzero-sum feedback game in extensive form, if:

- At the time of his act, each player has perfect information concerning the current level of play;
- Information sets of the first-acting player at every level of play are singletons, and the information sets of the other players at every level of play are such that none of them includes nodes corresponding to branches emanating from two or more different information sets of the first-acting player; and
- The single-act games correspond to the information sets of the first-acting player at each level of play are of the ladder-nested type, then the multi-

act game is called an N-person nonzero-sum feedback game in ladder-nested extensive form (Basar &Olsdor, 1982:115-116).

Every finite N-person nonzero-sum feedback game in ladder-nested extensive form admits a Nash equilibrium solution in behavioural strategies, which can be, determined recursively. A feedback (Nash) equilibrium is also more interesting and important than an open-loop (Nash) equilibrium, since the latter requires pre-commitment, while the former does not.

The central distinction between two-person games and multi-person games is likened to how a firm behaves when it is "hostile" to some firms but "friendly" towards others. The implications are clear if it is able to choose whom to help and whom to hurt, it is more problematic if it must choose either to help everybody or to hurt all firms, such as when choosing the contribution level to a public good (Rabin, 1993:1281).

4.7 The Stackelberg equilibrium solution

The Nash equilibrium solution concept provides a reasonable non-co-operative equilibrium solution for nonzero-sum games when the roles of the players are symmetric, that is, when no single player dominates the decision process. In chapter 3 (section 3.4.1.2) it was shown that there are other types of non-co-operative decision problems wherein one of the players has the ability to enforce its strategy on the other player(s), namely the Stakelberg leader. For such decision problems a hierarchical equilibrium solution concept is used.

Consider the bimatrix game (A, B) displayed in Table 4.6, with Vodacom (P1) and MTN (P2).

Table 4.6 Stackelberg normal form game

$$A = \begin{array}{c|c|c|c|} \multicolumn{1}{c}{} & \multicolumn{3}{c}{\textbf{MTN}} \\ \cline{2-4} L & 0^{S1} & 2 & \frac{3}{2}^{S2} \\ \cline{2-4} M & 1 & 1^{N} & 3 \\ \cline{2-4} R & -1 & 2 & 2 \\ \cline{2-4} \multicolumn{1}{c}{} & \multicolumn{1}{c}{L} & \multicolumn{1}{c}{M} & \multicolumn{1}{c}{R} \end{array} \ \textbf{Vodacom}, \qquad B = \begin{array}{c|c|c|c|} \multicolumn{1}{c}{} & \multicolumn{3}{c}{\textbf{MTN}} \\ \cline{2-4} L & -1^{S1} & 1 & -\frac{2}{3}^{S2} \\ \cline{2-4} M & 2 & 0^{N} & 1 \\ \cline{2-4} R & 0 & 1 & -\frac{1}{2} \\ \cline{2-4} \multicolumn{1}{c}{} & \multicolumn{1}{c}{L} & \multicolumn{1}{c}{M} & \multicolumn{1}{c}{R} \end{array} \ \textbf{Vodacom}$$

In table 4.6, this bimatrix game admits a unique Nash equilibrium solution in pure strategies, which is {M, M}, with the corresponding outcome being (1,0). Now, stipulating that the roles of the players are not symmetric and Vodacom can enforce his strategy on MTN. Then, before he announces his strategy, Vodacom has to take into account possible responses of MTN (the follower), and view of this, he has to decide on the strategy that is most favourable to him. If Vodacom chooses L, then MTN has a unique response (that minimises his cost) which is L, thereby yielding a cost of 0 to Vodacom. If Vodacom chooses, M, MTN's response is again unique (which is M), with the corresponding cost to Vodacom being 1. Finally, if he picks R, MTN's unique response is also R, and the cost to Vodacom is 2. Since the lowest of these costs is the first one, it follows that L is the most reasonable choice for Vodacom, in this hierarchical decision problem. Thus, L is the Stakelberg strategy of Vodacom in this game, and the pair {L, L} is the Stakelberg solution. Furthermore, the cost pair (0, 1) is the Stakelberg equilibrium outcome of the game. It should be noted that that this outcome is more favourable for both players than the unique Nash outcome, this is however not a rule.

The Stakelberg equilibrium solution concept is applicable to all two-person finite games in normal form, provided that the follower's response to every strategy of the leader is unique.

Thus, for:

γ^{1} and γ^{2} -are Vodacom's and MTN optimal responses respectively,

Γ - denotes the pure-strategy spaces of Vodacom and MTN and

$J^i(\gamma^1, \gamma^2)$ – is the cost incurred to Pi corresponding to a strategy pair $\{\gamma^1 \in \Gamma^1, \gamma^2 \in \Gamma^2\}$.

In a two-person finite game with Vodacom as the leader, a strategy $\gamma^1 \in \Gamma^1$ is called a Stakelberg equilibrium strategy for Vodacom, if:

$$\max_{\gamma^2 \in R^2(\gamma^{1*})} J^1(\gamma^{1,} \gamma^2) = \min_{\gamma^1 \in \Gamma^1} \max_{\gamma^2 \in R^2(\gamma^1)} J^1(\gamma^{1,} \gamma^2) \square J^{1*}$$

The quantity J^{1*} is the Stakelberg cost of Vodacom, with

$$R^2(\gamma^1) = \{\xi \in \Gamma^2 : J^2(\gamma^1, \xi) \leq J^2(\gamma^1, \gamma^2), \text{for all } \gamma^2 \in \Gamma^2\}$$

as the optimal response set of MTN to the strategy $\gamma^1 \in \Gamma^1$ of Vodacom (Basar & Olsdor, 1982:125-129).

Within the context of multi-act dynamic games, the Stakelberg equilibrium is suitable for the class of decision problems in which the leader has the ability to announce his decisions at all of his possible information sets ahead of time. Thus, the leader does not have the ability to announce and enforce his strategy at all levels of play prior to the start of the game, but can instead enforce his strategy on the follower(s) at every level of the game. Such a hierarchical equilibrium solution, which has the Stakelberg property at every level of play (but not globally), is called a feedback Stakelberg solution (Basar & Olsdor, 1982:130).

Extending Stakelberg to three persons (N = 3), there are then three different possible modes of play among the players:

- There are two levels of hierarchy in decision-making – one; leader and two; followers. The followers react to the leader's announced strategy by playing according to a specific equilibrium concept among themselves (for instance, Nash).
- There are still two levels of hierarchy in decision making – now two leaders and one follower. The leaders play according to a specific equilibrium

concept among themselves, by taking into account possible optimal responses of the follower.

- There are three levels of hierarchy. First P1 announces his strategy, then P2 determines his strategy by also taking into account possible responses of P3 and enforces this strategy on him, and finally P3 optimises his cost function in view of this announced strategies of P1 and P2 (Basar & Olsdor, 1982:140-141).

4.8 Entry deterrence

These models are possibilities by the current network providers (MTN and Vodacom) to expel entrants (Cell X) from the market.

4.8.1 Pre-emption

These models explain how a firm claims and preserves a monopolistic position. MTN and Vodacom have a dominant position by arriving first in this natural monopoly; or more generally, by early investments in research and product design, or durable equipment and other cost reduction (Aumann & Hart, 1992:307-313).

4.8.2 Signalling

Here MTN and Vodacom convey information reliably that discourages unprofitable entry of Cell X.

4.8.2.1 War of attrition

Attrition models study markets with excess numbers and examine the process that selects survivors. MTN and Vodacom are initially viable as monopolists then the net result is that the high-cost firm (Cell X) eventually exits; or if both have sufficiently low costs, then a duopoly persists forever (still only MTN and Vodacom) (Bulow & Klemperer, 1999:175).

4.8.2.2 Limit pricing

Studies of limit pricing examine the incentives of MTN and Vodacom to signal their private information about costs or demands to deter misguided entry. The motive is clearest in the case of an incumbent monopolist (such as Vodacom and MTN), with a privately known marginal cost, who anticipates that a potential entrant (Cell X) will enter if it perceives that its profits are lower for the entrant, (and higher for the incumbent) if the incumbent's cost is lower, and lower for the incumbent after entry. Moreover, prior to entry Cell X can observe the price chosen by MTN and Vodacom but not its marginal cost (Aumann & Hart, 1992:315-317).

4.8.3 Predation

Predation models aim to explain why MTN and Vodacom might willingly incur losses battling Cell X, as in a price war. The hypothesised motive is that the cost of the battle is an investment that pays off later, either by expelling the entrant or by deterring later entrants (Aumann & Hart, 1992:318).

4.9 Summary

In chapter three, it was established that traditional oligopoly theories do not do justice to the multitude of dynamic interactions, which could arise in an oligopoly. One approach to this problem involves the use of game theory, which has the added virtue of reinforcing the understanding of oligopolist interdependence. In game theory, the equivalent to the Cournot equilibrium is known as the Nash equilibrium, whereby no player has an incentive to change his (optimum) strategy even after the choices of all the players are revealed. These Nash equilibria are not only Pareto optimal but also coincide with the set of Walrasian equilibria.

In this chapter the use of game theory in oligopolistic market structures were examined. Section 4.2 a description of game theory was given. Game theory can be divided into two branches, cooperative and non-cooperative game theory. This study only examined non-cooperative game theory, because players in oligopolistic market structures seldom approach the fully collusive outcome.

In section 4.3 zero-sum games were examined in which the sum of the payoffs of all the players are zero whatever strategies they choose. Zero-sum games were examined through normal form and extensive form games. The most elementary type of two-person games is two-person zero-sum game in normal form (matrix). An extensive form involves a tree structure with several nodes and branches, providing an explicit description of the order of play and the information available to each player at the time of his/her decision(s). These extensive forms game can be transformed into normal form games.

In section 4.4 nonzero-sum games were examined through bimatrix games, which carries most of the silent features and intricacies of non-cooperative decision making. These bimatrix games equilibrium outcomes are known as Nash equilibria. Thereafter n-person nonzero-sum games where examined. The central distinction between two-person games and multi-person games is likened to how a firm behaves when it is "hostile" to some firms but "friendly" towards others. The implications are clear, if it is able to choose whom to help and whom to hurt, it is more problematic if it must choose either to help everybody or to hurt all firms, such as when choosing the contribution level to a public good.

Section 4.5 examined the Stackelberg equilibrium solution, where one of the players has the ability to enforce its strategy on the other player(s).

Finally, in section 4.6, entry deterrence models were examined. These models are possibilities by the current network providers (MTN and Vodacom) to expel the possible entrant (Cell X) from the market. These models include pre-emption, signalling, attrition, limit pricing and predation. In the following chapter game theory will be used to determine the impact of a new entrant into South Africa's cellular ICT sector.

Chapter 5: Using game theory to determine the impact of a new entrant into South Africa's cellular ICT sector.

5.1 Introduction

In the previous chapter the use of game theory in oligopolistic market structures was examined. It was illustrated that the traditional way of modelling oligopolistic behaviours does not adequately capture the multitude of dynamic interactions, which could arise in an oligopolistic market setting. Game theory gives a solution to this problem as it has the advantage of modelling oligopolistic interdependence.

In this chapter game theory will be used to model the effect that deregulation (i.e. a new entrant) will have on South Africa's cellular sector. Firstly an overview of the bidding process and the bidders is given in section 5.2. In section 5.3 the possible benefits of the new entrant to the economy as whole is examined. In section 5.4 the benefits the new entrants will have on the cellular sector is examined. In section 5.5 game theoretic modelling will be used to determine the possible result equilibrium of the entrance of the third cellular operator.

5.2 Bidding process of South Africa's third cellular licence

In 1994 when the government licensed South Africa's existing cellphone duopoly, it undertook not to allow more competition into the market until it was satisfied that there was room for more players (Lloyed, 1998:28). Currently (2000) South Africa's cellular network providers enjoy benefits such as high margins, low variable costs, strong cash flows, limited competition, and low exposure to bad debts (Gray, 2000:26).

Just one year after its origination in February 1997, SATRA commissioned an enquiry into the economic feasibility of the provision of more than two mobile cellular telecommunication services.

Section 27(9) of the Telecommunications Act 103 of 1996 together with section 37 (2)(b) requires the Authority to hold this enquiry within two years of the coming into effect of the Act.

SATRA held the enquiry in 1998 and found that a third cellular service would be feasible (Gov. Gazette 19115, notice 1526, 1998). On 26 February 1999 the Minister issued "the invitation" by Government Gazette 19806, Notice 314 of 1999. Subsequently SATRA appointed Afcent/CLC Consortium Consultants to assists in regulatory, technical and related assistance in the process leading up to, and including, issuance of a third mobile cellular telecommunications licence (SATRA, 2000).

In February 2000 SATRA recommended Cell C as the winning bidder. After allegations that the Presidents Office interfered into the license bid, SATRA had to go through a re-adjudication process. They re-recommended Cell C as the winning bidder. One of the losing bidders, NextCom, applied for a court interdict to prevent the Minister of communication from confirming Cell C as the winning bidder. The court issued an injunction, stating that the Minister must wait, pending the outcome of a judicial review of the bidding process (Cellular, 2000).

5.2.1 The bidders

Consider Table 5.1, where an overview of the five bidders is given.

Table 5.1: Bidders for South Africa's third cellular licence

Bidder	**Foreign shareholding**	**Empowerment shareholding**	**Funding**	**Positives**	**Negatives**
Africa Speaks Cellular	30% SB Telecom	51%	$700m peak funding secured	If Satra likes CDMA technology it could win Overseas firms Telesystem International Wireless, Invetcom and Crown Castle help with rollout. Local partner is Tellumat.	Mismatch of tecnologies. Plans a combination of CDMA and GSM networks, with an iDen at a later date. This means 3 sets of infrastructure and skills. Romano accused of self-enrichment
Cell-C	60% Oger Telecom	40%	$506m, underwritten by Saudi Oger	Have cash and skills of first tier operator. Saudi Oger guarantees no dilution of black empowerment shares. It is obligated to dilute its stake to an entrenched minimum of 30%	US$1bn corruption allegations against Hariri denied as baseless. GTE is merging with Bell Atlantic is in a US mobile phone joint venture with Airtouch Vodafone. Potential for collusion denied by GTE
Five Mobile Network	12,5% GTIB-Elgadphon	52,5%	Peak funding of R1, 8bn. Total investment of R3, 3bn. 50% committed from shareholder equity	Entry level charge of 15c/minute for local calls innovative voice mail service, good distribution channel. In line with government's rural development strategy.	Financing is subject to licence award. Won't challenge MTN and Vodacom's urban markets

Source (Haffaje & Bidoli, 2000:42)

Table 5.1: Bidders for South Africa's third cellular licence (continued)

Bidder	Foreign shareholding	Empowerment shareholding	Funding	Positives	Negatives
Khulama 084	51% MSI	49%	$500m committed. Expects to invest R6bn in first 10 years	Strong franchising model, significant funding committed, strong financial and technical plan	Telecel – involved in a cellular licensing row in Zimbabwe. Detecon exercised its option for equity after original bid. Ibrahim accused of self-enrichment but he is risking millions of his own funds.
Nextcom	40% Distacom	60%	Peak investment of R5, 6bn 76% committed. Commutative capes of R13bn by 2006	Distacom strong in "lifestyle" marketing. Has had success as a late cellular entrant in first world and developing countries. Consumers will benefit from price cuts and simple pricing plans. Strong distribution channel.	Critics say it has too many shareholders, that it has overintglated its bid and that its business case is unsustainable. Union Alliance Media and Disability Employment Concerns Trust are founder shareholders in troubled e.tv. Questions about Distacom's financial position and success of overseas operations.
Telia Telenor	51% Telia Telenor	26%	R700m R4bn peak funding by 2004	First tier operators with 26 cell operations in developed and developing markets. Good understanding of GSM and advanced radio technologies. Track record of technical and operational capabilities and ability to raise finance.	Controversy because it brought in Afrozone as shareholder after the June 14 deadline. Rivals claim bid is not complaint and that TT is arrogant and not committed to SA. Telia is closely aligned to MTN in other African ventures.

Source: Haffaje & Bidoli, 2000:42.

In the above table the six bidders for South Africa's third cellular license are given. Each bidder's foreign shareholders, empowerment shareholding, funding is given as well as some positive – and negative aspects.

The evaluation criteria for considering the applications for the licence derived from the provisions of the Telecommunications Act, No 103 of 1996. Due regard was given to applications by persons from historically disadvantage groups according to section 35(3) of the Act.

In accordance with the objectives and responsibilities set out in the Act, the Authority stated in 1999 that the applications would be evaluated under the following main criteria, to which the following weights were attached (Gov gazette notice no 20090, notice 956 of 1999):

- Business plan and investment strategy - 44%
- Empowerment - 25%
- Impact on the telecommunications industry and consumers - 7%
- Technical plan - 13%
- Universal service - 11%.

5.3 Benefits of new entrant on the economy

A period of co-ordinated and significant trade liberalisation, in a number of service sectors at once, could have a number of other positive macroeconomic side-effects that may increase the potential benefits to a country undergoing the process. These effects are likely to be small if only one sector is liberalised at a point in time.

- The simultaneous reductions in prices, in a number of service and related sectors, through productivity improvements could lower inflationary pressures significantly for a period in a country. This may allow for the reduction of real interest rates without fear of significant inflationary outcomes. Lower real interest rates should allow the expected output expansion in the affected sectors to occur but also crowd in more private investment in unrelated sectors.
- Because commercial presence is a prerequisite for most telecommunications service trades, the liberalising of trade will lead to a round of foreign investment in a country. For developing countries this is important as it means that a significant amount of the new investment will not place a strain on the balance of payments.
- A period of price stability and higher growth, bought on by widespread liberalisation, may crowd in more investment as expectations of future returns increase. The impact of higher growth rates on foreign investment patterns has been shown to be significant.

- The co-ordinated demand increase from a number of service markets undergoing liberalisation may bring about a sufficient market demand for a number of common inputs which may assist in establishing an industry or producer service in a developing country.
- The process of enhancing productivity growth through numerous service sectors at once would require human resource training to bring about these improvements. This should raise the overall level of human capital in a country (Hodge, 1999b:33).

5.3.1 Effect of new entrant in other industries

Many gains for developing countries are actually with the downstream users of the intermediate services. The source of up-and downstream benefits arises from the fact that both service industries are an important intermediate input into all sectors of the economy. The range of possible downstream benefits include:

- Increased demand for productivity enhancing inputs – the process of improving productivity in response to deregulation will most likely result in increased demand for selective inputs to bring about these changes. These are most likely to be business services, new capital equipment, technology licensing, education services and financial services. The extent to which this demand is realised locally depends on the import-intensity of these inputs.
- Increased investment demand for capital goods – it has been noted that deregulation is likely to result in demand expansion drop price reductions and product innovation. The increased output will require additional investment in capital goods to support expansion. The extent to which the local economy benefits will depend on the import intensity of capital goods.
- Increased ongoing demand for intermediate inputs – this increase in output will result in increased demand for supplier inputs. Table 2.1 in chapter 2 shows which industries are likely to benefit the most.
- Price reduction for sectors in which the sector is an intermediate input – lower prices in the sector feed into lower prices for other industries. These

lower input prices may lead to lower prices in these industries too, which in turn will expand output, to an extent determined by their price and income demand elasticity's. This impact is likely to be significant due to the huge scope for price reductions.

- Productivity improvements for sectors in which the sector is an intermediate input – growth in the quality and variety of intermediate inputs can result in improving productivity and growth in final goods production. This occurs as either less input is required, due to its higher quality, or the more specialised input is more closely tuned to the needs of the industry and so has a greater productivity impact. New services might just make productivity enhancements feasible in downstream industries. These productivity improvements in downstream industries may lead to price reductions and demand expansion if significant.
- Scale effects – the expansion of demand in a number of linked sectors could lead to scale efficiency benefits, increasing efficiency and lowering marginal costs.
- Price reductions in a number of sectors increase the real income of consumers, which feeds through to a general increase in the level of domestic demand. Demand patterns, and the impact of changes in relative prices on these patens, will determine which industries benefit most from demand increases.

The extent to which lower input prices and productivity enhancing improvements in service intermediates lead to price reduction and demand expansion in domestic final good industries depends in part on the market structure in those industries. As South Africa's Telecommunication sector will be oligopolistic in nature with the entrance of the new network provider, these improvements may not feed into lower prices but higher margins and so weaken the demand expansion effect.

Further, the total price reduction and output expansion is a result, not just of these first round effects, but also of future rounds of similar effects as the price reductions and output expansions in other industries feed into higher demand for the services than have been liberalised on other sectors.

For potential demand to be realised, there needs to be an environment that is conductive to investment in output expansion, including low or dropping real interest rates (Hodge, 1999b:31-32).

5.3.2 Opportunities for new operator

The new cellular operator's opportunities can be defined by the following parameters:

- Quality;
- Price;
- Coverage;
- Value-added services; and
- Technology platform.

There is no single value proportion that will meet the needs of the business, the personal contract, the pre-paid and the potential subscribers. A different mix of the parameters that make up the value proportion is required to tackle the needs of the different market segments (Gray, 2000:38).

An important point Cell C will also note about South Africa's cellular sector is that most cellular users are not loyal to their current operators. If the newcomer is able to offer a good quality service, cheaper pricing and national coverage, it could clean up the market. A study by BMI-TechKnowledge (BMI-T) showed that more than 70% of South Africa's cellular users would jump ship if the new operator offered a national service at cheaper prices. Notably there has not been a price war between MTN and Vodacom. There is a huge opportunity to win black customers, who have until now, been largely ignored. Another key finding in the report was that 44% of current users did not compare the MTN and Vodacom offerings when acquiring their service, which suggests that the operators' branding has not struck home (Bidoli, 1999b:85).

Branding and distribution will also be the new entrant's (Cell X) keys to success. If Cell X does not build the similar kind of brand desirability that

Orange achieved in the UK, it may fail, irrespective of the excellent engineering that the network might have (Haffajee & Bidoli, 2000:44).

5.3.3 New operator's effect on cellular prices and output

Telecommunication services is about the only service sector where analysts expect deregulation will result in expected gains in output and lower prices. The output gains are expected as few leakages occur to cross-border suppliers. This is in large part attributable to the high degree of market expansion that is likely to occur from improved innovation and not the smaller static gains.

The OECD (1996) estimates for a few OECD countries are presented in table 5.2 below.

Table 5.2: OECD estimates, 1996

	USA	*Japan*	*Germany*	*France*	*UK*
Output Prices	-6%	-16%	-23%	-30%	-13%
Sectoral Output, of which	13%	23%	41%	45%	21%
Price induced	3%	8%	11%	15%	6%
Innovation induced	10%	15%	30%	30%	15%

Source: Hodge, 1999b:27.

From the above table, price reductions range from 6% for the relatively liberal USA telecommunications sector to 30% for the more restricted French sector. Output increases by between 13% to 45%, with roughly 70% coming from product innovation.

The introduction of competition through deregulation will result in increasing the elasticity of demand faced by the incumbent, forcing them to move closer to a more efficient marginal cost-pricing regime. It is important to note that increased competition in telecommunications comes not only from those using the same technology, but also those using alternative technologies (Hodge, 1999b:27).

Internationally, new competition has meant a reduction in prices and improvement in services. ING Barings forecasts that in nominal terms, tariffs will be constant through to 2007. In real terms, however, they expect prices to decline by 32%, against Western Europe's drop of 45%. Operators like Orange, the fourth GSM operator in the UK, showed that it is possible to start from behind and be successful through innovative marketing and good service (Haffajee & Bidoli, 2000:42-43).

The effect of the third cellular license has lead the two existing operators to lower their prices and cut barriers to subscriber entry. This has enabled more people to obtain cellular service before the entry of the third operator, thus increasing MTN and Vodacom's share of the market (Gray, 2000:40).

5.3.4 Chances new operator will exit market

Network providers' entry costs to the industry are significantly high. Not only must the new operator (Dorfling, 1998:14) pay a once-off license fee of R100-million. The new operator's peak funding requirement will be more than R4bn (with a 50-50 dept:equity ratio). To date MTN and Vodacom have each spend around R10bn on their networks. Making entry and exit extremely costly. Thus, the entrance of the new operator is unlikely to result in the exit of existing firms (Haffajee & Bidoli, 2000:46).

This does not mean that the market share of each operator will be reduced, suggesting a loss of scale efficiency, because:

- Studies of OECD countries suggested that the market expansion effects of deregulation of telecommunications markets are extremely large. OECD (1996) suggests that in protected markets, such as France and Germany, the markets could expand by over 40% (Hodge, 1999b:28).
- Network providers operate well above efficient scale already.

- Technology gains grow exponentially, reducing prices and increasing opportunities (Hazelhurst, 2000:49).
- New entrants will not wish to operate at a less efficient scale than existing firms as it would put them at a cost disadvantage (Hodge, 1999b:28).

5.3.4.1 Productivity gains from new entrant

The introduction of greater competition is likely to result in an immediate reduction of inefficient business practices in domestic firms, serving to lower marginal costs. The lowering of prices through lower price-costs margins and opportunities for scale efficiencies will force domestic firms to adopt the available domestic best practice production technologies to retain profitability. The alternative is to see profits squeezed to the point where they may be forced to exit the market, or have their market share reduced to the point where they start to lose scale efficiency too. This process is a reduction of X-inefficiency and not an improvement in technological frontiers. Empirical evidence from manufacturing firms facing increasing import competition suggests that average productivity increases as the dispersion of productivity levels amongst firms decreases through inefficient firms exiting or improving (Hodge, 1999b:28).

5.3.4.2 Dynamic benefits from innovation and productivity growth

Competition will influence the rate of process and product innovation in the telecommunications sector and therefore facilitate South Africa to 'close the technological gap' with other countries and realise higher rates of productivity improvement and product innovation. The mechanisms that achieve this are:

- Increased competition from deregulation improves the incentive to innovate/imitate, in the long run, as producers of new products displace producers of old products. Cell C is coming in with a newer generation of technology. This should enable them to offer different products in different areas (Haffajee & Bidoli, 2000:43)
- Trade or FDI will help firms get access to foreign know how. As limitation is often less costly than innovation, the rate of technological progress

should accelerate. Exposure to a larger knowledge base should also accelerate their innovation through having an additional idea source.

- Trade may expand the service market (either by exports or domestic expansion from price-cost margin reductions) which improves the return to innovation and so increase the innovative effort (Hodge, 1999b:29).
- These effects differ from the static gains where a firm improves productivity once off to the level of domestic best practice. Under the dynamic gains from trade, firms accelerate their technological growth rate and so should come closer to 'catching-up' with word best practice.
- The counter-argument is that when learning-by-doing is the most important source of technological gains, then temporary protection may be the best policy to allow domestic firms to gain that experience and improve productivity sufficiently to compete. The emphasis is that protection needs to be temporary otherwise there is no incentive to move down the learning curve. In the case of telecommunications this argument probably holds little credibility for a number of reasons:
- Competition takes place through commercial presence, except for international services. Therefore, failure by domestic firms to learn rapidly means that foreign firms who produce on domestic soil anyway replace them.
- Foreign providers entering will still use a high portion of local labour, which must go through the same learning curve as incumbents, which allows incumbents, time to learn. Further, in the case of network providers significant time may pass until the network is fully operational and with high coverage.

The high sunk cost of network providers means that they are not going to be destroyed by competition and therefore have time to learn (Hodge, 1999b:29).

Table 5.3: Labour and capital productivity of telecommunications network providers, 1994.

	USA	Japan	Germany	France	UK
Capital Productivity Index (Call minutes per unit of capital service, 1994, USA=100)	100.0	46.0	38.0	N/A.	N/A.
Potential Impacts of reform					
Labour productivity	10%	15%	30%	40%	20%
Capital productivity	10%	40%	40%	50%	20%
Innovation effect on output	10%	15%	30%	30%	15%

Source: Hodge, 1999b:30.

Table 5.2 above measures labour and capital productivity of telecommunications network providers in 1994 and their estimates of potential impact of deregulation reforms. This table is taken from OECD (1996) and provides an indication of how large these benefits from productivity improvements and product innovation can be. It could be noted that even amongst industrial countries, the productivity levels could vary considerably – mostly due to a lack of competition and trade. Such lags in productivity imply that when reform is implemented, the potential productivity improvements are highly significant, up to 40% improvement in labour productivity and 50% improvement in capital productivity. What is equally impressive, is the estimation that catching up with lags, in product innovation in these markets, could expand market demand between 10-30%. Growing Internet usage has a significant impact on these figures.

The size of all these numbers reflects how fast process and product innovation has been occurring in the telecommunications sector, and continues to occur. Continuing to uphold monopoly market structures is only gong to result in a widening of the productivity of the productivity and product range gap with counties like the USA. As this gap widens, so does the cost of not reforming these markets and the penalty to the domestic users of telecommunication services (Hodge, 1999b:30).

5.4 Analysing South Africa's cellular sector

South Africa's oligopolistic cellular market structure was analysed in chapter three. It showed that for Vodacom and MTN to set their prices, they need to know how their sales would respond to a change in its prices. In other words, they need some idea of the demand curve they face (MR), as opposed to the market demand curve. As these two firms don't compete in a competitive market, they will produce a quantity so that their price will exceed their marginal costs, meaning that they are likely to face a downward-sloping demand curve.

As Vodacom and MTN's prices exceed their marginal costs, a natural way to measure this monopoly power is to examine the extent to which the profit-maximising price exceeds marginal cost. The mark-up ratio of price minus marginal cost to price is used to determine this, also known as the rule of thumb of pricing (Robert & Rubinfeld, 1995:332-335):

$$P = \frac{MC}{1+(1/E_d)}$$

This relationship provides a rule of thumb for any firm with monopoly power, w here E_d is the elasticity of demand for the firm, and not the elasticity of market demand. It is harder to determine the elasticity of demand for the firm than for the market because the firm must consider how its competitors will react to price changes (Watson & Holman, 1977:34-35). Essentially, the manager must estimate the percentage change in the firm's unit sales that is likely to result from a 1 percent change in the price the firm charges. This estimate is usually based on the manager's intuition and experience. Given an estimate of the firm's elasticity of demand, the manager can calculate the proper mark-up. If the firm's elasticity demand is large, this mark-up will be small (firm has very little monopoly power). If the firm's elasticity of demand is small, this mark-up will be large (firm will have considerable monopoly power)

5.4.1 Sources of market power.

Monopoly power is the ability to set price above marginal cost, and the amount by which price exceeds marginal cost depends inversely on the firm's elasticity of demand. However, why do some firms face a demand curve that is more elastic, while others face one that is less elastic? Three factors determine a firm's elasticity of demand.

5.4.1.1 The elasticity of market demand

If there is only one firm (pure monopolist) its demand curve is the market demand curve. Then the firm's degree of monopoly power depends completely on the elasticity of market demand. However, if several firms compete with one another, then the elasticity of market demand sets a lower limit on the magnitude of the elasticity of demand for each firm.

5.4.1.2 The number of firms

The second determinant of a firm's demand curve, and hence its monopoly power, is the number of firms in the market. The monopoly power of each firm will fall as the number of firms increase. As more and more firms compete, each firm will find it harder to raise prices and avoid losing sales to other firms. An important aspect of competitive strategy is finding ways to create barriers to entry (Robert & Rubinfeld, 1995:338-339).

5.4.1.3 The interaction among firms

Firms might compete aggressively, undercutting one another's prices to capture more market share. This would probably drive prices down to nearly competitive levels. Each firm will be afraid to raise its price for fear of being undercut and losing its market share, and thus it will have little or no monopoly power. On the other hand, the firms might not compete much. They might even collude (in violation of antitrust laws), agreeing to limit output and raise prices. Raising prices in concert rather than individually is more likely to be profitable, so collusion can generate substantial monopoly power (Robert & Rubinfeld, 1995:339-340).

5.4.2 Pricing with market power

The problem the managers of firms (in monopolistic market structures) have is how to use their market power most effectively. They must decide how to set prices, choose quantities of factor inputs, and determine output in both the short and long run to maximise the firm's profit. Managers of firms with market power have a harder job than those who manage perfectly competitive firms. Managers of firms with monopolistic power must also obtain information about the characteristics of demand. Even if they set a single price for the firm's output, they must obtain at least a rough estimate of the elasticity of demand to determine what that price (and corresponding output level) should be.

A manager wants to apply a price strategy that will capture consumer surplus and transfer it to the producer. Producers know that some customers would pay more. Raising price would mean losing some customers, selling less, and earning smaller profits. Similarly, other potential customers are not buying the firm's product because they will not pay a price as high as the market price. Many of the consumers, however, would pay prices higher than the firm's marginal cost. By lowering its price, the firm could sell to some of these customers, but it would then earn less revenue from its existing customers, and again profits would shrink.

A solution to this problem is that the firm might charge different prices to different customers, according to where the customers are along the demand curve. This is the basis of price discrimination – charging different prices to different customers. The problem is to identify the different customers, and to get them to pay different prices.

South Africa's cellular telecommunication sector is an example of second-degree price discrimination. Consumers may purchase talk-time minutes monthly, but their willingness to pay declines with increasing consumption. In this situation Vodacom and MTN discriminated according to the quantity consumed through different contracts and pre-paid airtime. This price discrimination works by charging different prices for different quantities or "block" of the same good or service (Robert & Rubinfeld, 1995:361-368).

5.5 Game theoretic modelling of South Africa's cellular ICT sector

Given the discussion in sections 5.2 – 5.4, the necessary assumptions can now be identified to use game theory to investigate the possible result equilibrium after entrance of third cellular operator.

Consider a hypothetical duopoly game between Vodacom and MTN before entry of new operator. For simplicity, assume that the firms set only one price for its product.

So that:

q_i = the number of items (in thousands) produced by company i (i = 1,2).

AC_i = the average production cost per item for company i.

$TC_i = q_i \bullet AC_i$ = the total production cost (in R1 000) for company i.

$MC_i = \frac{d(TC_i)}{dq_i}$ = the marginal cost, the cost per item of raising production slightly, for company i.

p = the price per item at which the commodity can be sold.

$P_i = q_i \bullet p - TC_i$ = the profit (in R1 000) of company i.

With Vodacom and MTN's average cost functions:

$AC_{Vodacom} = 64 - 4q_{Vodacom} + q_{Vodacom}^2$ $\qquad$ $AC_{MTN} = 80 - 4q_{MTN} + q_{MTN}^2$

the average cost per item varies with the quantity produced.

For both Vodacom and MTN the average cost per item at first, decreases due to economies of scale. It reaches a minimum at $q = 2$ and then begins to increase, as the company has to invest more capital and hire more labour to increase production further. Vodacom is more efficient than MTN, and can produce the commodity at R16 less per item at any level of production.

Taking the derivatives for the marginal costs:

$$TC_{Vodacom} = 64q_{Vodacom} - 4q_{Vodacom}^2 + q_{Vodacom}^3 \qquad TC_{MTN} = 80q_{MTN} - 4q_{MTN}^2 + q_{MTN}^3$$

$$MC_{Vodacom} = 64 - 8q_{Vodacom} + 3q_{Vodacom}^2 \qquad MC_{MTN} = 80 - 8q_{MTN} + 3q_{MTN}^2$$

Assuming a relationship between the total quantity produced and the price per item, at which the commodity can be sold, the demand function is:

$$p = 300 - 20(q_{Vodacom} + q_{MTN}).$$

If the items are rare they can be sold for R160 each, but as production increases and the market becomes glutted, the price must be lowered to sell all of the items produced. Vodacom and MTN face a very elastic demand curve (E_d = -20).

Vodacom and MTN's profits can now be derived:

$$P_{Vodacom} = q_{Vodacom}(300 - 20q_{Vodacom} - 20q_{MTN}) - (64q_{Vodacom} - 4q_{Vodacom}^2 + q_{Vodacom}^3)$$

$$= 236q_{Vodacom} - 16q_{Vodacom}^2 - q_{Vodacom}^3 - 20q_{Vodacom}q_{MTN}$$

and similarly

$$P_{MTN} = 220q_{MTN} - 16q_{MTN}^2 - q_{MTN}^3 - 20q_{Vodacom}q_{MTN}.$$

Each company's goal is to choose its production level q_i so as to maximise its profit P_i. But each company's profit is determined not only by its own choice of production level, but also by the other company's choice through the mixed term $-20q_{Vodacom}q_{MTN}$. Consider the following two-person game:[1]

Table 5.4 Duopoly game between MTN and Vodacom

q_{MTN}

		1	2	3	4	5
	1	(199;183)	(179;328)	(159;429)	(139;480)	(119;475)
	2	(360;163)	(320;288)	(280;369)	(240;400)	(200;375)
$q_{Vodacom}$	3	(477;143)	(417;248)	(357;309)	(297;320)	(327;275)
	4	(544;123)	(464;208)	(384;249)	(304;240)	(224;175)
	5	(555;103)	(455;168)	(355;189)	(255;160)	(155;75)

(Profits in R1 000)

Making use of Gambit[1], game theoretic software (California institute of technology & University of Minnesota, 2000), this game has a unique Nash equilibrium solution of $q_{Vodacom} = 4, q_{MTN} = 3$. This is an outcome where neither player can raise it's own profits P_i by changing q_i (MR = MC). It can be show as follows:

$$\frac{\partial P_{Vodacom}}{\partial q_{Vodacom}} = 236q_{Vodacom} - 16q_{Vodacom}^2 - q_{Vodacom}^3 - 20q_{Vodacom}q_{MTN} = 0$$

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[1] Gambit is a library of game theory software and tools for the construction and analysis of finite extensive and normal form games. Gambit is designed to work on both Microsoft Windows (95/98/NT) and Unix platforms.

$$\frac{\partial P_{MTN}}{\partial q_{MTN}} = 220q_{MTN} - 16q_{MTN}^2 - q_{MTN}^3 - 20q_{Vodacom}q_{MTN} = 0.$$

The solution to the set of equations is $q_{Vodacom} = 4$ and $q_{MTN} = 3$. The price is (R300 – 20(4+3)) = R160, and the profits are R384 million to Vodacom and R249 million to MTN. This equilibrium is known as a Nash-Cournot equilibrium.

5.5.1 Entrance of the new operator

Consider now a game with the entrance of new operator (Cell X), with hypothetical average cost function: $AC_{CellX} = 100 - 4q_{CellX} + q_{CellX}^2$, which is less efficient than Vodacom and MTN (economies of scale). With the relationship between the total quantity produced and the price per item at which the commodity can de sold now to be:

$$p = 300 - 30(q_{Vodacom} + q_{MTN} + q_{CellX})$$

With the firm's new profits functions being:

$$P_{Vodacom} = 236q_{Vodacom} - 26q_{Vodacom}^2 - q_{vodacom}^3 - 30(q_{Vodacom}q_{MTN} + q_{Vodacom}q_{CellX})$$

$$P_{MTN} = 220q_{MTN} - 26q_{MTN}^2 - q_{MTN}^3 - 30(q_{MTN}q_{Vodacom} + q_{MTN}q_{CellX})$$

$$P_{CellX} = 100q_{CellX} - 26q_{CellX}^2 - q_{Cellx}^3 - 30(q_{CellX}q_{Vodacom} + q_{CellX}q_{MTN})$$

Given Cell X's cost function, it will be able to consider the following two strategies: $q_{CellX} = 1$ and $q_{CellX} = 2$.

Table 5.5 Oligopoly game between Vodacom, MTN and Cell X (option 1)

$\underline{q_{CellX} = 1}$

q_{MTN}

		1	2	3
	1	(152,136,16)	(122,220,-14)	(92,246,-44)
$q_{Vodacom}$	2	(252,106,-14)	(192,160,-44)	(132,156,-74)
	3	(294,76,-44)	(204,100,-74)	(114,66,-104)

Table 5.6 Oligopoly game between Vodacom, MTN and Cell X (option 2)

$\underline{q_{CellX} = 2}$

q_{MTN}

		1	2	3
	1	(122,106,-20)	(92,160,-80)	(62,156,-140)
$q_{Vodacom}$	2	(192,76,-80)	(132,100,-140)	(72,66,-200)
	3	(204,46,-140)	(114,40,-200)	(24,-24,-260)

In the above multi-player game Gambit determines that the unique Nash equilibrium is $q_{Vodacom}$ = 3, $q_{MTN} = 2$, $q_{CellX} = 1$, giving payoffs of R294 million to Vodacom, R76 million to MTN and a loss of R-44 million to Cell X. With the current market demand a higher price (R180) must be asked in order to for the firms to produce at their optimum level of production.

Vodacom and MTN must now decide if they are going to “accommodate” Cell X by maintaining a higher price, in the hope the Cell X will do the same. As seen Vodacom and MTN’s profits will decrease because they will have to share the market.

Alternatively Vodacom and MTN could try to create a barrier to entry for Cell X. Vodacom and MTN are currently producing at their optimum level of output (MC = MR). This means that Vodacom and MTN can not just lower their prices, as they will then be producing at an inefficient production level. Vodacom and MTN know that they are facing a very elastic demand curve (E_d = -20). So the only way for Vodacom or MTN to lower their prices and still produce at an optimum level of output is to invest in the extra capacity needed to increase output and engage in competitive warfare.

Assume that Vodacom and MTN invest R20 million in extra capacity to build, maintain, and operate. Consider Cell X’s incentive to enter or not.

Table 5.7 Entry deterrence by Vodacom and MTN (option 1)

$\underline{q_{CellX} = 0}$

q_{MTN}

		2	3	4
	3	(152,136,16)	(122,220,-14)	(92,246,-44)
$q_{Vodacom}$	4	(252,106,-14)	(192,160,-44)	(132,156,-74)
	5	(294,76,-44)	(204,100,-74)	(114,66,-104)

Table 5.8 Entry deterrence by Vodacom and MTN (option 2)

$\underline{q_{CellX} = 1}$

q_{MTN}

		2	3	4
	3	(122,106,-20)	(92,160,-80)	(62,156,-140)
$q_{Vodacom}$	4	(192,76,-80)	(132,100,-140)	(72,66,-200)
	5	(204,46,-140)	(114,40,-200)	(24,-24,-260)

In the above game Gambit determines that the Nash equilibrium is where Vodacom produces 3, MTN 2 and Cell X 0. This is because Cell X now knows that entry will result in warfare, so it is rational for Cell X to stay out of the market. Because Vodacom and MTN now have additional capacity, they will do better in competitive warfare, than maintaining a high price and earning a profit of R274 million to Vodacom and R140 million to MTN, having deterred entry.

Effective strategizing will be an utmost necessity not only for the new entrant to survive but also for consumers to partake in long-term economic welfare benefits.

5.6 Summary

The previous chapter determined that the traditional way of modelling oligopolistic behaviours does not adequately capture the multitude of dynamic interactions, which could arise in an oligopolistic market setting. In this chapter game theory is used to model what effect deregulation will have on South Africa's cellular sector.

In this chapter game theory was used to determine the impact of a new entrant into South Africa's cellular ICT sector. The bidding process of South Africa's third cellular licence as well as the bidders for the third cellular licence where examined in section 5.2.

In section 5.3 the benefits of a new cellular operator on the economy where examined. The gains for developing countries (like South Africa) are with the downstream users of the intermediate services. The source of up-and-downstream-benefits arises from the fact that both service industries are an important intermediate input into all sectors of the economy.

The telecommunications services is about the only service sector where analysts expect deregulation will result in expected gains in output and lower prices. However, network providers' entry costs to the industry are significantly high, amplifying the need for effective strategizing, as exiting the market will be very costly. It was found that branding and distribution will be the new entrant's (Cell X) keys to success. If Cell X does not build the similar kind of brand desirability that Orange achieved in the UK, it may fail, irrespective of the excellence of the network.

In section 5.4 South Africa's cellular sector was analysed. In an oligopolistic market structure as South Africa's cellular ICT sector, the operators (MTN and Vodacom) have monopoly power, giving them the ability to set prices above marginal cost. However, the amount by which the price exceeds the marginal cost depends inversely on the firm's elasticity of demand. That is why it is important for managers of firms with monopolistic power to obtain information about the characteristics of the demand that they are facing.

Finally in section 5.5 game theoretic modelling was used to investigate the possible result equilibrium after the entrance of the third cellular ICT operator. Hypothetical games where used for modelling. Firstly, the duopoly game between MTN and Vodacom was simulated. Thereafter the entrance of the new operator (Cell X) was simulated by using a hypothetical cost function that was less efficient than Vodacom and MTN (economies of scale). If Cell X enters the market and Vodacom and MTN "accept" this new entrant, Vodacom and MTN will produce less at a higher price to accommodate Cell X, meaning that Cell X will produce less than MTN and at a loss (at first due to high sunk costs).

However, Vodacom and MTN are facing an elastic demand curve (hypothetically), meaning that a raise in prices might lead to a loss of customers. So if Cell X tries to enter this market at a lower price than Vodacom and MTN Cell X will still make a loss at first, but might be able to build up a bigger client base, causing even Vodacom and/or MTN to loose some of their customers.

A threat like this might cause Vodacom and MTN to try and deter the entry of Cell X by investing into extra capacity. Because Vodacom and MTN will have additional capacity, they will do better in competitive warfare, than maintaining a high price. Simulating this situation showed that it would not be feasible for Cell X to enter the market. Causing Vodacom and MTN to hold on to their monopolistic position. Effective strategizing will be an utmost necessity not only for the new entrant to survive but also for consumers to partake in long-term economic welfare benefits. Chapter six will now conclude.

Chapter 6: Summary, conclusion & recommendations

6.1 Summary

The cellular ICT can make a valuable contribution to the economic development of countries and regions. The internationalisation of services is at the very core of economic globalisation. Service industries provide links between geographically dispersed economic activities and thus play a fundamental role in the growing interdependence of markets and production activities across nations (Archibugi & Michie, 1997:4).

If South Africa, and indeed Africa, wish to partake in the benefits of globalisation, promotion of the cellular ICT may be a vital part of any economic development strategy. Africa comprises 20 percent of the world's landmass and contains 12 percent of its population. But it accounts for only 2 percent of the world's telecommunications (Noam, 1999:3). It is especially in the wireless communication industry where Africa, including South Africa, can benefit from recent technological advances. According to Zysman et al. (2000:107) the wireless communication industry is undergoing a revolution. Within the next two years, the number of worldwide mobile and personal communications subscribers is expected to exceed half a billion. Within the next five years, the number of wireless subscribers is expected to surpass the number of worldwide wireline subscribers. If Africa is to start "bridging the digital divide" it should consider strategies to increase the access of its populations to wireless communication services.

Mobile cellular communications was launched in South Africa in 1994, with Vodacom and MTN as the two network operators. This sector has had an annual growth rate of 50 percent. As a result of this rapid growth South Africa is the largest Global System for Mobile Communications (GSM) technology network outside of Europe and is the fourth fastest growing GSM market in the world (Hodge, 1999a:17).

MTN and Vodacom (duopology) are now facing the entrance of the new cellular network provider possibly in late 2001 or 2002. Whereas the current market structure is one of duopoly, the future structure will be oligopolistic. In such a structure, the pricing and marketing behaviour of firms would be different, and the welfare implications may be different (Antinou, 1993:285).

The role of the government should be to create a regulatory environment that facilitates the rapid growth of all networks (Hodge & Miller, 1997:4). In November 1999 one more license was awarded by the South African Telecommunications Regulatory Authority (SATRA) (Hodge, 1999a:24).

It may be argued that the deregulation of South Africa's cellular sector may be welfare-improving if it leads to improved communication links and a decrease in costs. As the price-quality mix of producers services (i.e., services that are inputs into the production of other goods and services) improve this has a positive feedback effect in terms of the demand for services. It allows firms to specialise in their core competencies and outsource needed inputs, benefiting from improved communication and coordination links (Hoekman & Primo Braga, 1997:4). In this study game theory will be used to investigate whether the outcome of the deregulation of the cellular ICT industry in South Africa may be welfare-improving. Game theory will suggest an optimal solution in the face of an opponent who has a strategy of its own.

In chapter two South Africa's cellular ICT was analysed. Firstly, the role of this sector in South Africa's economy was examined in section 2.2. It was found that ICT services play a key role in any economy – from being an important intermediate input to business, an enabling medium for a range of content providers, a significant item in household expenditure, and finally a source of demand for numerous manufacturing and service industries.

In section 2.3 the range of services that can operate on a particular network were discussed. It was found that the range of services that operate on a particular network depends on the technology of that network. An overview of South Africa's service providers was given in section 2.4, because due to deregulation network and services provided the ICT industry have been separated from each other in South Africa.

In section 2.5 South Africa's, current cellular ICT sector was examined. Firstly, from Telkom's limited mobile phone service till in 1994 when digital phone technology and deregulation lead to South Africa's introduction of mobile cellular communications. Today, feature-rich, handheld phones are available countrywide from network providers, MTN and Vodacom, at a fraction of the original cost. In 2000 there are almost 4m subscribers, with Vodacom having the largest share of this market (58% of the subscribers). South Africa has experienced significant growth in the industry of around 50% per annum, since it's launch, providing industry revenues of roughly R4 billion per annum. Making South Africa the largest GSM technology network outside Europe and the fourth fastest growing GSM market in the world.

In section 2.6 this industry's nature of production and forms of trade were analysed. As the duopoly of Vodacom and MTN are by the end of 2000 facing the entrance of a new cellular operator which will result in an oligopolistic market structure. Depending on the equilibrium between market participants, the long-awaited licensing of this new operator may thus result in an improvement in quality, market penetration and services.

The equilibrium between market participants depends on the market structure the participants are in.

In chapter three South Africa's imperfect competition cellular ICT sector was examined. In section 3.2 imperfect competition was defined and examined through non-cooperating and cooperating models. Firstly, Cournot – and Stackelberg models were used to examine non-cooperating oligopolistic market structures. Here was found that the market output under a Cournot oligopoly lies between the competitive output and the monopoly output, and the Cournot output converges to the competitive output as the number of firms increases. In the Stackelberg model one of the firms may decide to take advantage of its relative size and adopt a different strategy than the one implied by Cournot. In this model firms are aware that its own level of output has an effect on the market price and therefore on the optimum level of output of its opponent. It is however, not a fact that the Stackelberg leader will earn higher profit as the follower can expect to earn a higher profit than the leader for any finite conditional variance of the signal. The Stakelberg firms produce more combined than their monopoly or Cournot counterparts, at lower price, but less than the competitive level.

Cartelism were used to examine cooperating oligopolies, where collusion occurs when the firms in an oligopoly realise that they can jointly increase their profit by raising the product's price and working out an agreement for dividing the market. Formal cartels are illegal in South Africa, however imperfect cartels are still formed and are usually the result of an implicit agreement on production quotas amongst members.

Section 3.3 examined the economic welfare impact of South Africa's cellular ICT sector to determine if this market is functioning at an optimum production point and if that point is the best optimum point in the market.

Section 3.4 examined the structure of South Africa's cellular ICT sector. The reason why some markets are more concentrated than others are due to economies of scale. Telecommunications is a technological intensive industry, which was traditionally viewed as a natural monopoly, due to high sunk costs. South Africa's cellular ICT sector has also significant barriers to entry, preventing new firms from competing on an equal footing with the existing firms.

Competition in South Africa's cellular ICT sector is not price driven, as a change in price may be a dangerous strategy for an oligopoly. This is only one of the multitude of dynamic interactions in oligopolies that none of the examined oligopoly theories do justice to. It is not reasonable for one firm to assume that the other firm's behaviour will not be strategic. In fact, an oligopolist must spend a great deal of effort in forecasting his rivals' response to any action that it takes. One approach to this problem involves the use of game theory, which has the added virtue of reinforcing our understanding of oligopolist interdependence.

In chapter four the use of game theory in oligopolistic market structures were examined. Section 4.2 a description of game theory was given. Game theory can be divided into two branches, cooperative and non-cooperative game theory. This study only examined non-cooperative game theory, because players in oligopolistic market structures seldom approach the fully collusive outcome.

In section 4.3 zero-sum games were examined in which the sum of the payoffs of all the players are zero whatever strategies they choose. Zero-sum games were examined through normal form and extensive form games. The most elementary type of two-person games is two-person zero-sum game in normal form (matrix). An extensive form involves a tree structure with several nodes and branches, providing explicit description of the order of play and the information available to each player at the time of he/she decision(s). These extensive forms game can be transformed into normal form games.

In section 4.4 nonzero-sum games were examined through bimatrix games, which carries most of the silent features and intricacies of non-cooperative decision making. These bimatrix games equilibrium outcomes are known as Nash equilibria. Thereafter n-person nonzero-sum games where examined. The central distinction between two-person games and multi-person games is likely to how a firm behaves when it is "hostile" to some firms but "friendly" towards others. The implications are clear if it is able to choose whom to help and whom to hurt, it is more problematic if it must choose either to help everybody or to hurt all firms, such as when choosing the contribution level to a public good.

Section 4.5 examined the Stackelberg equilibrium solution, where one of the players has the ability to enforce its strategy on the other player(s).

Finally, in section 4.6, entry deterrence models were examined. These models are possibilities by the current network providers (MTN and Vodacom) to expel the possible entrant (Cell X) from the market. These models include pre-emption, signalling, attrition, limit pricing and predation. In the following chapter game theory will be used to determine the impact of a new entrant into South Africa's cellular ICT sector.

In chapter five game theory was used to determine the impact of a new entrant into South Africa's cellular ICT sector. The bidding process of South Africa's third cellular licence as well as the bidders for the third cellular licence where examined in section 5.2.

In section 5.3 the benefits of a new cellular operator on the economy where examined. The gains for developing countries (like South Africa) are with the downstream users of the intermediate services. The source of up-and-downstream-benefits arises from the fact that both service industries are an important intermediate input into all sectors of the economy.

The telecommunications services is about the only service sector where analysts expect deregulation will result in expected gains in output and lower prices. However, network providers' entry costs to the industry are significantly high, amplifying the need for effective strategizing, as exiting the market will be very costly. It was found that branding and distribution will be the new entrant's (Cell X) keys to success. If Cell X does not build the similar kind of brand desirability that Orange achieved in the UK, it may fail, irrespective of the excellence of the network.

In section 5.4 South Africa's cellular sector was analysed. In an oligopolistic market structure as South Africa's cellular ICT sector, the operators (MTN and Vodacom) have monopoly power, giving them the ability to set prices above marginal cost. However, the amount by which the price exceeds the marginal cost depends inversely on the firm's elasticity of demand. That is why it is important for managers of firms with monopolistic power to obtain information about the characteristics of the demand that they are facing.

Finally in section 5.5 game theoretic modelling was used to investigate the possible result equilibrium after the entrance of the third cellular ICT operator. Hypothetical games where used for modelling. First the duopoly game between MTN and Vodacom where simulated. Thereafter the entrance of the new operator (Cell X) was simulated, by using a hypothetical cost function that was less efficient than Vodacom and MTN (economies of scale). If Cell X enters the market and Vodacom and MTN "accept" this new entrant, Vodacom and MTN will produce less at a higher price to accommodate Cell X, meaning that Cell X will produce less than MTN and at a loss (at first due to high sunk costs).

However, Vodacom and MTN are facing an elastic demand curve (hypothetically), meaning that a raise in prices might lead to a loss of customers. So if Cell X tries to enter this market at a lower price than Vodacom and MTN Cell X will still make a loss at first, but might be able to build up a bigger client base, causing even Vodacom and/or MTN to loose some of their customers.

A threat like this might cause Vodacom and MTN to try and deter the entry of Cell X by investing into extra capacity. Because Vodacom and MTN will have additional capacity, they will do better in competitive warfare, than maintaining a high price. Simulating this situation showed that it would not be feasible for Cell X to enter the market, causing Vodacom and MTN to hold on to their monopolistic position.

6.2 Conclusion

The problem managers of firms (in monopolistic market structures) have is how to use their market power most effectively. They must decide how to set prices, choose quantities of factor inputs, and determine output in both the short and long run to maximise the firm's profit. Managers of firms with market power have a harder job than those who manage perfectly competitive firms. Managers of firms with monopolistic power must also obtain information about the characteristics of demand. Even if they set a single price for the firm's output, they must obtain at least a rough estimate of the elasticity of demand to determine what that price (and corresponding output level) should be.

This study determined that the traditional way of modelling oligopolistic behaviours does not adequately capture the multitude of dynamic interactions which could arise in an oligopolistic market setting and that one approach to this problem involves the use of game theory, which has the added virtue of reinforcing our understanding of oligopolistic interdependence.

6.3 Recommendations

If the new cellular entrant wishes to become a significant player in South Africa's cellular ICT sector it will have to be pro-active. Effective strategizing will be an utmost necessity not only for the new entrant to survive but also in order for consumers to partake in the long-term economic welfare benefits.

Effective strategizing would require the use of tools such as game theory to be able to determine prices, choose quantities of factor inputs, and determine output in both the short and long run to maximise the firm's profit.

References

ACHTERBERG, R. 1999. Competition policy and regulation: a case study of telecommunications. (Paper delivered at TIPS 1999 annual forum at Glengurn Lodge, 19 – 22 Sep. 1999.) Muldersdrift. 21 p. (Unpublished.)

ALEXANDER, I. & ESTACHE, A. 1999. The role of regulation reform and growth: lessons from Latin America. (Paper delivered at TIPS 1999 annual forum at Glengurn Lodge, 19 – 22 Sep. 1999.) Muldersdrift. 24 p. (Unpublished.)

ARCHIBUGI, D. & MICHIE, J. 1997. Technology, globalisation and economic performance. London : Cambridge University Press. 301 p.

ARTHUR ANDERSEN & PROXIMA SYSTEMS WORLDWIDE STRATEGIC ALLIANCE. 1999. Cambridge telecom report November 29. [Fulltext on Computer select database, March 2000].

ANTONIOU, A. 1993. Applied micro economics. 2nd ed. Durban : Butterworths. 469 p.

AUMANN, R.J. & HART, S. 1992. Handbook of game theory with economic applications. Amsterdam : North-Holland. 733 p.

BASAR, T. & OLSDER, G.J. 1982. Dynamic noncooperative game theory. New York : Academic Press. 149 p.

BASSON, D. 1996. 'n Voorbeeld van banke gemaak. Finansies & tegniek, 48(31):9-11, Aug.

BIDOLI, M. 1998. Unlocking door into Africa. Financial mail, 149(5):92, May.

BIDOLI, M. 1999a. Telecoms regulations. Financial mail, 152(11):81-82, Mar.

BIDOLI, M. 1999b. Three is really not a crowd. Financial mail, 153(4):85, Apr.

BIDOLI, M. 1999c. Who'll get the Nigerian competition. Financial mail, 154(5):66, Jul.

BIDOLI, M. 1999d. Third cellular phone network. Financial mail, 155(6):44-47, Oct.

BIDOLI, M. & MCLEOD, D. 1998. Stomping around in their playpens. Financial mail, 149(11):79-80, Jul.

BRYANT, W.D.A. 1994. Misinterpretations of the second fundamental theorem of welfare economics: barriers to better economic education. Journal of economic education, 25(1):75-81, Winter.

BT CELLNET. 2000. Homepage. [Web:] http://www.cellnet.co.uk [Date of access: 20 May 2000].

BULOW, J. & KLEMPERER, P. 1999. The generalized war of attrition. The American economic review, 89(1):175-188, Mar.

CALIFORNIA INSTITUTE OF TECHNOLOGY & UNIVERSITY OF MINNESOTA. 2000. Gambit version 0.96.3. [Web:] http://www.hss.caltech.edu/gambit/Gambit.html [Date of access 15 Dec. 2000].

CAMPBELL, K. 1999. SA cellular sector falling short. Martin Creamer's engineering news, 19(30):5, Aug.

CAVE, J. 1987. Long-term competition in a dynamic game: the cold fish war. The rand journal of economics, 18(4):596-610, Winter.

CELLULAR. 2000. Homepage. [Web:] http://www.cellular.co.za [Date of access: 15 November 2000].

CHEN, Y. 1993. Cooperative and predatory advertising: effects on oligopoly advertising investment. Atlantic economic journal, 21(2):26-39, Jun.

COZZI, G. 1999. R & D cooperation and growth. Journal of economic theory, 86(1):17-49, May.

D'ASPREMONT, C. & FERREIRA, R.D.S. 1991. Pricing schemes and Cournotion equilibria. American economic review, 81(3):666-674, Jun.

DE FRAJA, G. & STADERINI, A. 1996. An empirical analysis of competition in brand differentiated oligopoly. International journal of economics for business, 3(1):57-68, Feb.

DU MHANGO, D. 1999. Foreign direct investment in South Africa: how has the policy towards FDI worked and how can it be strengthened? [Web:] http://www.tips.co.za [Date of access: 19 July 2000].

DORFLING, C. 1998. Two new cell operators by June. Martin Creamer's engineering news, 18(47):14, Dec.

EDLIN, A.S. & EMCH, E.R. 1999. The welfare losses from price-matching policies. Journal of industrial economics, 47(2):145-168, Jun.

FERSHTMAN, C. 1984. Goodwill and market shares. Economica, 51:271-281, Aug.

FRIEDMAN, D.D. 1990. Price theory. 2nd ed. Cincinnati : South-Western Publishing. 627 p.

GAL-OR, E. 1991. A common agency with incomplete information. The rand journal of economics, 22:274-286, Summer.

GAUDET, G. & SALANT, S.W. 1991. Increasing the profits of a subset of firms in oligopoly models with strategic substitutes. American economic review, 81(3):658-666, Jun.

GEORGE, K.D. & JOLL, L. 1986. Industrial organisation. 3rd ed. London : George Allen & Unwin. 336 p.

GOLD, S. 1999. Telecom investing failing to meet expectations. [Fulltext on Computer select database, March 2000].

GORDON, G. 1998. The awarding of two new cellular network licences by the South African Telecommunications Regulatory Authority. Financial mail, 150(4):95-96, Aug.

GRAY, T. 2000. SA's cellphone market booms. Business technology, 5(4):36-46, May.

HAFFAJEE, F. & BIDOLI, M. 2000. Why Cell C won 084. Financial mail, 157(1):42-47, Mar.

HAMILTON, S.F. & SANDIN, R. 1997. Subsidies in oligopoly markets: a welfare comparison between symmetric and asymmetric costs. Public finance review, 25(6):660-669, Nov.

HAYES, F. & SOPHISTER, S. 1995. Is game theory useful for the understanding of decision making in economic settings? [Web:] http://www.maths.tcd.ie/pub/econrev/ser/html/game.html [Date of access: 21 May 2000].

HAZELHURST, E. 2000. Making the connection. Financial mail, 156(8):48-49, Feb.

HEYLICHEN, F., JOSLYN, C. & TURCHIN, V. 2000. Game theory. [Web:] http://www.pespmcl.vub.ac.be/asc/game_theor.html [Date of access: 25 May 2000].

HODGE, J. 1998a. Developing a trade and industrial policy agenda for the services sector in South Africa. (Paper delivered at TIPS second workshop on services organised at the IDRC boardroom 9th floor, Braamfontein Centre on 23 October 1998.) Johannesburg. 56 p.

HODGE, J. 1998b. South African trade in high technology products. [Web:] http://www.tips.co.za [Date of access: 18July 2000].

HODGE, J. 1999a. The state of the telecommunications industry and the potential costs/benefits of liberalisation. (Paper delivered at TIPS 1999 annual forum at Glenburn Lodge, 19-22 Sep. 1999.) Muldersdrift. 47 p. (Unpublished.)

HODGE, J. 1999b. Examining the costs of services protection in a developing country: the case of South Africa. [Web:] http://www.tips.co.za [Date of access: 18 July 2000].

HODGE, J. & MILLER, J. 1997. Developing an information technology policy for South Africa. Trade & industry monitor, 2:1-7, Jul.

HOEKMAN, B. & PRIMO BRAGA, G.A. 1997. Protection and trade in services: a survey. London : Centre for economic policy research (CEPR). 36 p. (Discussion paper no 1705.)

HSIEN, W. & HSING, Y. 1994. Impact of deregulation on returns of scale in telecommunications. Atlantic economic journal, 22(1):104, Mar.

ICHIISHI, T. 1983. Game theory for economic analysis. New York : Academic Press. 164 p.

JEHIEL, P. & MOIDOVANU, B. 2000. License auctions and market structure. London : Centre for economic learning and social evaluation (ELSE). [Web:] http://www.else.econ.ucl.ac,uk [Date of access: 15 Dec 2000].

JOHNSON, L.W., REISS, R.D. & ARNOLD, J.T. 1993. Introduction to linear algebra. 3rd ed. New York : Addison-Wesley. 534 p.

JUSTMAN,M. 1996. A welfare analysis of innovation in R&D markets. International journal of social economics, 23(2):52-66, Feb.

KARP, L.S. 1993. A dynamic model of oligopoly in the coffee export market. American journal of agricultural economics, 75(2):448-458, May.

KREPS, D.M. 1993. Game theory and economic modelling 3rd ed. New York : Oxford University Press. 195 p.

LAING, R. 1998. Two up for cellphone users. Finance week, 76(31),:16-18, Aug.

LAING, R. 1999. Vodacom rings up Tanzania. Finance week: 53, Jul.

LAMBERTINI, L. 1997. Prisoners' dilemma in duopoly (super) games. Journal of economic theory, 77(1):181-191, Nov.

LINDSEY, D. 1988. Microeconomics. 5th ed New York : Dryden Press. 519 p.

LLOYED, T. 1998. Facing the third force. Finance week, 76(14):28, Apr. 9.

MAKOWSKI, L. & OSTROY, J.M. 1995. Appropriation and efficiency: a revision of the first theorem of welfare economics. American economic review, (85(4):808-828, Sep.

MALONE, T.A. 1998. Evolving oligopolies. Physician executive, 24(2):30-33, Mar.

MALUEG, D.A. 1994. Monopoly output and welfare: the role of curvature of the demand function. Journal of economic education, 25(3):235-251, Summer.

MASKIN, E. 1999. Nash equilibrium and welfare optimality. Review of economic studies, 66(1):23-38.

MATHIS, S. & KOSCIANSKI, J. 1995. Entry preemtion through capacity expansion in the US titanium industry. International advances in economic research, 1(4):431-446, Nov.

MCAFEE, R., PRESTON, R. & MCMILLAN, J. 1996. Competition and game theory. Journal of marketing reseach, 33(3):263-268, Aug. [Fulltext on EBSCO Business source premiere database, Dec 2000].

M-CELL. 2000. Homepage. [Web:] http://www.m-cell.co.za [Date of access: 20 Nov 2000].

MEISTER, J.P. 1999. Oligopoly: an in class economic game. Journal of economic education, 30(4):383-392, Fall.

MTN. 2000. Homepage. [Web:] http://www.mtn.co.za [Date of access: 20 May 2000].

NOAM, E.M. 1999. Telecommunications in Africa. New York : Oxford Univerity Press. 305 p.

ONE-2-ONE. 2000. Homepage. [Web:] http://www.one-2one.co.uk [Date of access: 20May 2000].

ORANGE. 2000. Homepage. [Web:] http://www.orange.co.uk [Date of access: 20 May 2000].

O'SIOCHRU, S. 1996. International experience and the South African effort. Ottawa : International development research centre. 104p.

PERMAN, L. 1996. SA's cellular romance. Finance week, 70(5):69-70, Jul.

PINDYCK, R.S. & RUBINFELD, D.L. 1995. Microeconomics. 3rd ed. New Jersey : Prentice Hall. 699 p.

PRICE, G.N. 1995. Consumer discrimination, duopoly, and black firm entry: the welfare effect of subsadies. Review of black political economy, 23(4):69-77, Spring.

RASMUSEN, E. 1992. Games and information: an introduction to game theory. 4th ed. Oxford : Blackwell. 352 p.

RABIN, M. 1993. Incorporating fairness into game theory and economics. American economic review, 83(5):1281-1303, Dec.

ROBERTS, M. & SAMUELSON, L. 1988. An empirical analysis of dynamic nonprice competition in an oligopolistic industry. The rand journal of economics, 19(2):200-220, Summer.

ROBERTS, M.J. 1984. Testing oligopolistic behaviour. International journal of industrial organization, 2:367-383, Jun.

ROBSON, A.J. 1990. Stakelberg and Marshall. American economic review, 80(1):69-83, Mar.

ROLLER, L.H. & WAVERMAN, L. 2000. Telecommunications infrastructure and economic development: a simultaneous approach. London : Centre for economic policy research. 21p. (Discussion paper no 2399.)

ROSENBULT, J. 1998. Telecommunications in Chile: success and post-deregulation challenges in a rapidly emerging economy. Journal of international affairs, 51(2):565-582, Spring. [Fulltext on EBSCO Academic search elite database, Mar 2000].

SAKAR, J. & BARNALI, G. 1998. A geometric solution of a Cournot oligopoly. Journal of economic education, 29(2):118-123, Spring.

SAMPSON, G.P. & SNAPE, R.H. 1985. Identifying the issues in trade in services. The world economy, 8(2):171-182.

SATRA. 2000. Homepage. [Web:] http://www.satra.gov.za [Date of access: 20 Dec 2000].

SELTEN, R. 1975. Re-examination of the perfectless concept for equilibrium in extensive games. International journal of game theory, 4(1):22-25.

SHINKAI, T. 2000. Second mover disadvantages in a three-player Stackelberg game with private information. Journal of economic theory, 90(2):293-304, Feb.

SLADE, M.E. 1994. What does an oligopoly maximize? The journal of industrial economics, 42:45-61, Mar.

SLADE, M.E. 1995. Empirical games: the oligopoly case. Canadian economics association, 28(2):369-402, May.

SLOTH, B. 2000. Why study game theory? [Web:] http://www.econ.ku.dk/sloth/gametheory/why.htm [Date of access: 10 Oct 2000].

SOUTH AFRICA. 1996. Telecommunications Act, No. 103 of 1996. Government gazette : 19412, 1392, Oct. 30.

SOUTH AFRICA. Department of Communication. 1996. White paper on Telecommunications policy. [Web:] http://www.polity.org.za/govdocs/white_papers/1998.telewp.htm [Date of access: 13 Nov. 2000].

SOUTH AFRICA. 1998. Competition Act, No. 89 of 1998. Government gazette : 19412, 1392, Oct. 30.

SOUTH AFRICA. Department of Environmental affairs and Tourism. 1998. Environmental conservation act, 73 of 1989. Government gazette : 19115 : 1526, Nov. 27.

SOUTH AFRICA. Department of Communications. 1999. Invitation to apply for one mobile cellular telecommunication service licence in terms of section 34(2)(a)(ii) of the Telecommunications act, 1996. Government gazette : 19806, 314, Feb. 26.

SOUTH AFRICA. SATRA. 1999. Information document with regard to the third mobile cellular telecommunication service licence applications. Government gazette : 20090, 956, May 14.

SOYODE, A. 1999. International investment flows in South Africa: performance and prospects. (Paper delivered at TIPS 1999 annual forum at Glenburn Lodge, 19-22 Sep. 1999.) Muldersdrift. 15 p. (Unpublished.)

SPILLER, P.T. & FAVARO, E. 1984. The effects of entry regulation on oligopolistic interaction: the Uruguayan banking sector. The rand journal of economics, 15(2):244-254.

STRAFFIN, P.D. 1993. Game theory and strategy. Washington : The mathematical association of America. 244 p.

TAYLOR, K.S. 1998. Human society and the global economy. [Web:] http://online.bcc.ctc.edu/econ100/ksttext [Date of access: 20Jul 2000].

TELCOM AFRICA 2000. 2000. 10th Conference and exhibition on telecommunications in Africa, 3-7 May, Gallagher Estate, Midrand, South Africa.

TELKOM. 2000. [Web:] http://www.telkom.co.za [Date of access: 20May 2000].

TREBING, H.M. 1996. Achieving coordination in public utility industries: a critique of troublesome options. Journal of economic issues, 30(2):561-571, Jun.

VAN DER KOOY, R. 1999. Telecommunications. Finance week: 9, Dec.10.

VODACOM. 2000. Homepage. [Web:] http://www.vodacom.co.za [Date of access: 20May 2000].

VODAFONE. 2000. Homepage. [Web:] http://www.vodafone.co.za [Date of access: 20May 2000].

WALLSTEN, S.J. 1999. Telecom traffic and investment in developing countries. [web;] http://wbln0018.worldbank.org/research/workpapers.nsf/(allworkingpapers)/ [Date of access: 15 March 2000].

WATSON, D.S. & HOLMAN, M.A. 1977. Price theory and its uses. 4th ed. Boston : Houghton Mifflin Company. 445 p.

ZYSMAN, G.I., TRALLO, J. A., HOWARD, R.E., FREIDENFELDS, J., VALENZUELA, R.A. & MANRIEWICH, P.M. 2000. Technology evolution for mobile and personal communications. Bell lab technical journal, 1(1):107-129, Jan.