BIDS FOR THE UMTS SYSTEM: AN EMPIRICAL EVALUATION

OF THE ITALIAN CASE
by

P.L. Scandizzo[*] and M. Ventura[**]

This article surveys the main economic and technical features of the UMTS system. Once defined the general legal scheme in which European countries operate, the article focuses on the Italian case, analysing the legal background regulating the license assignment, and providing an empirical evaluation of the bid held in November 2000. Applying a theoretical model, we highlight and estimate some of the key variables of the problem, such as the parties' bargaining power, the maximum willingness to pay, the optimal time length of the concession.

Introduction

With the closure of the twentieth century and the opening of the new millennium, we are witnessing a far reaching change in the communication sector, which has effected, and is still going to effect for a long time, the production system and our own lifestyle. The product of this impressive and rapid mutation has been denoted as the *new economy*. A very important part of the new economy world, we can say its last “child”, in time order, is the UMTS.

[*] Università di Roma Tor Vergata.
[**] ISAE, Istituto di Studi e Analisi Economica, Roma

The Universal Mobile Telecommunications System, UMTS, should take the personal communications user into the Information Society of the 21st century. It will deliver advanced information directly to people and provide them with access to new and innovative services. It promises to offer mobile personalised communications to the mass market regardless of location, network or terminal used.

The next five years of innovation in the telecommunication industry, according to the UMTS Forum, will play an important part in determining a momentous change in lifestyle and business, that carries many personal and economic benefits. Personal competitiveness in business relies more and more on increased personal productivity and responsiveness. Globalisation of organisations and trade produces the need for multi-company virtual teams. At the same time, the desire for freedom and leisure time in our personal lives is being met by different means, not the least of which is a completely new mixture of one's work and private life.

Mobility, the newest ingredient of the telecommunications systems, complies with these new desires and needs. Existing and future mobile communications, in particular, appear to converge with new standards of information and entertainment content, consumer electronics and computing. This phenomenon, which occurs as the result of advances in technology, in areas such as multimedia [1] computing, digital and interactive TV and the Internet, promises to lay the foundation for the development of a fully global " Information Society", all over the world.

UMTS networks will provide enhanced easy access for everyone to public service databases and to other people's data, information and communication, thereby facilitating the trend

---

[1] Network multimedia may be defined to include services such as pay-TV; video- and audio-on-demand; interactive entertainment; education and information service; and communication services such as video telephony and fast, large file transfer.

towards flexible working practices, with a significant contribution to employment. While UMTS aims to reach the mass market in order to satisfy consumer demands for personal mobile communications, however, its success is highly dependent on the prices subscribers will have to pay for the equipment and service usage.

In this paper we propose a model of evaluation of the UMTS system , based on the value of the licences assigned, with an application to the Italian case. The plan of the paper is as follows. In section 1 we describe the services provided by the new technology. In section 2, we consider the global market growth for the system. In section 3, we present and discuss the evolution of the European market for UMTS services, the composition of sector revenue for Europe, and , using the UMTS Forum forecast[2], the estimate of the size of the Italian share of the European market. In section 4, we describe the lineaments of the legal and regulatory background. Section 5 is devoted to the presentation of the theoretical model and section 6 to the empirical application to the Italian case. Section 7 presents some conclusions.

1. SERVICES PROVIDED BY UMTS TECHNOLOGY.

The UMTS Forum identifies, and accordingly provides revenue forecasts, for six basic categories of services, representing the bulk of demand for 3G services over the next years. The six service categories are defined from a user perspective and are intended to reflect the perception of the market. Rather than the voice-centric environment, that has dominated the mobile world to date, 3G will be an always-on data environment. Enabling a standard based on “anytime, any place connectivity”, the Internet users will be able to add mobility to their fixed Internet experience, through the **Mobile Internet**

[2] UMTS Forum Report no. 9-13, in the relative annexes.

Access service for the residential market segment and the **Mobile Intranet/Extranet Access** for the business segment.

But mobility is not the only benefit provided by cellular networks. Mobile cellular networks, in fact, have two distinctive features that distinguish them from fixed networks: (i) the mobile terminal is associated with a person rather than a place and, (ii), the network knows the current location of that terminal. Association of a terminal with a person allows the provision of a whole range of Internet-based content services, which could be termed as **Customised Infotainment**[3] services, tailored to the needs of the user and delivered through mobile portals.

The association of a terminal with a person also creates the opportunity for messaging services. The dramatic growth in short message service (SMS) traffic in GSM networks illustrates the demand for such messaging capabilities. The always-on characteristic of 3G networks will enable instant messaging capability, and the high data rates available will add image and video capability to create a **Multimedia Messaging Service (MMS)**.

Knowledge of the current location of a mobile terminal (which may be associated with a person or a machine) is already generating a rich portfolio of **Location-Based Services**. Again, the combination of always-on connectivity and multimedia capability available with 3G adds a new dimension to this type of services. Location technology not only enables specific Location-Based Services but also enhances other services such as Customised Infotainment and will be a major driver for the creation of new applications.

Voice will inevitably continue to be an important service offered in the 3G environment. High data rates will allow the addition of videophone capabilities to traditional voice services, giving rise to the **Rich Voice** service. Even though boundaries among these service categories are somewhat artificial and there is not an always clear-cut division among services, we will not

[3] Information and entertainment.

consider the problem of discriminating among different services. For the purpose of our analysis we will focus instead only on the gains arising from the UMTS licence. In this context, the service categories described provide a framework for the analysis of market demand and of industry trends. They highlight the essential differences between the mobile and fixed environments, and incorporate the major lessons from the experience of data services in the 2G environment.

Hereafter, we propose a summary table of the service categories just mentioned indicating the corresponding market segments.

Table 1. Services that represent the majority of the 3G Demand.

Service Name	**Service Description**	**Market Segment Analysed**
Mobile Internet/Extranet Access	A business 3G service that provides mobile access to corporate Local Area Network (LAN), Virtual Private Networks (VPNs), and the Internet.	Business
Customised infotainment	A consumer 3G service that provides device independent access to personalised content anywhere, anytime via structured-access mechanism based on mobile portals.	Consumer
Multimedia Messaging Service	A consumer 3G service, that offers non-real-time, multimedia messaging with always-on capabilities allowing the provision of instant messaging. Targeted at closed user groups that can be services provider or user-defined.	Consumer
Mobile Internet Access	It includes full Web access to the internet as well as file transfer, email, and streaming video/audio capability.	Consumer
Multimedia Messaging Service (Business)	It offers non-real-time, multimedia messaging with always-on capabilities, customisation, and user-to-user networking and allows the provision of instant messaging. Targeted to closed business communities that can be services provider or customer defined.	Business
Location-Based Services	A business and consumer 3G service that enables users to find other people, vehicles, resources, services or machines. It also enables customers to find other users, as well as users to identify their own location via terminal or vehicle identification.	Consumer and Business
Rich Voice and Simple Voice	A 3G service in real time and two-way mode. It provides advanced voice capabilities (voice activated net access and Web-initiated voice calls), while still offering traditional mobile voice features. As the service matures, it will include mobile videophone and multimedia communications.	Consumer and Business

Source: UMTS Forum

2. WORLDWIDE MARKET EVOLUTION.

Forecasts for services reported hereafter have been derived by UMTS Forum from **Telecompetition ATIVA Research Tools**, a research group that estimates country-level market size in four dimensions: time, product, segment and geography.

In developing the demand forecast, it was assumed that the 3G mobile industry would follow much of the business models and revenue structure of the fixed industry. The underlying key assumption is that different services would be offered under different business models, as described earlier. Therefore, the revenue sources for each service would also differ. For example, the Mobile Intranet/Extranet Access service would consist of subscription and airtime/access revenues only, while Customised infotainment offered through mobile portal would consist of subscription, transaction, advertising and airtime/access revenues.

Nature and size of future market position and business relationships between fixed Internet and mobile portals are highly uncertain. It is clear that both have strengths and are capable of capturing significant market shares. Therefore, for modelling purposes, it was assumed that by 2010, market shares are equally distributed among the two systems. The potential for new mobile data services, however, is not limited to the Internet. Services such as Rich Voice, Multimedia Messaging Service, and Location-based Services can be offered on non-Internet platforms and new devices.

When moving from a voice-centric to a data-centric environment, a distinction needs to be made between subscribers and subscriptions. The term “subscribers” refers to the users, while the term “subscriptions” refers to the services they use. In this report, the sum of the service subscriptions forecast will exceed the total number of 3G subscribers, since some subscribers will have more than one service subscription. (For example, a 3G user could subscribe both Customised Infotainment and Multimedia Messaging Service).

Revenue estimates are developed using known willingness-to-pay for analogous services, that meet similar needs and are targeted to similar markets. The underlying assumption in this approach is that users will be willing to pay at least as much for 3G services as they currently pay for existing fixed, mobile or other services. Thus there is no mobility premium attributed to the service price assumptions. In table 2, we present the forecast for the evolution of revenues for 3G, differentiated by service. The revenue forecasts are for revenues retained by mobile services providers only. They do not include market revenues of other players, such as content providers, device manufacturers and e-commerce partners. In all steps of the analysis, plausible prices and numbers have been used to reflect revenue flows of an achievable level. This approach can be considered conservative and establishes an average price level for services based on known willingness to pay. It does not presume a price structure, thus still allowing for a usage-sensitive pricing scheme, that would enable services providers to manage capacity by charging more bandwidth intensive users with higher prices. We have also assumed that users will compare fixed and mobile service pricing and will make rational choices. These are defined as those choices, that will maximise the expected value of their mix of mobile and fixed communication services.

Table 2. Worldwide revenues for 3G services, 2001-2010.
(billions of dollars[4] and average growth rates, 2005-2010)

Revenues	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**CAGR 2005-2010**
Customised Infotainment	0.0	0.7	5.8	11.2	17.0	31.9	48.1	53.7	64.3	85.8	38.2
Mobile Internet/ Extranet	0.0	0.9	3.1	5.9	8.5	15.3	23.6	34.1	47.4	60.7	48.2
MMS (Consumer)	0.0	0.2	1.6	3.6	5.1	8.8	11.8	13.2	15.4	17.8	28.4
Mobile Internet	0.0	0.2	0.8	1.5	2.2	3.9	6.0	8.7	9.6	14.2	45.2
MMS (Business)	0.0	0.0	0.4	0.9	2.2	5.7	10.3	16.5	22.2	25.0	62.6
Location-Based-Service	0.0	0.0	0.7	1.8	2.7	3.9	5.8	6.8	7.8	9.9	29.7
Rich Voice	0.0	0.0	0.0	0.1	0.7	1.4	4.2	8.1	13.6	20.8	97.1
Simple Voice	0.1	1.0	6.4	12.4	18.6	36.3	54.2	60.2	72.3	87.8	36.4
Total	**0.1**	**3.0**	**18.8**	**37.4**	**57.0**	**107.2**	**164.0**	**201.3**	**252.6**	**322.0**	**41.4**

Source: UMTS Forum

[4] All prices and revenues are quoted in 2001 US dollars.

Table 3. Worldwide subscriptions for 3G services, 2001-2010.
(millions and average growth rates, 2005-2010)

Subscriptions	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	CAGR 2005-2010
Customised Infotainment	0.0	2.6	20.7	39.7	58.5	109.8	168.2	190.1	230.4	311.1	39.7
Mobile Internet/ Extranet	0.1	1.2	7.2	14.2	25.8	58.1	92.4	137.1	196.3	258.2	58.5
MMS (Consumer)	0.0	1.0	6.9	17.2	27.3	53.1	79.4	88.2	105.8	128.5	36.3
Mobile Internet	0.0	0.3	1.8	3.6	6.6	14.8	23.6	34.9	39.6	60.3	55.7
MMS (Business)	Subscription numbers for MMS (Business), Rich Voice and Location-Based-Services are not meaningful, as these service revenues are a summation of several components, some of which are not calculated on a per-subscription basis										
Location-Based-Service											
Rich Voice											
Simple Voice	0.3	3.0	22.0	47.2	78.9	170.8	283.5	349.9	466.6	629.9	51.5

Source: UMTS Forum

As shown in table 3, worldwide subscribers are expected to grow dramatically, especially during 2005-2010. The demand forecast assumes that customised infotainment will be offered through a mobile portal. It includes subscriptions, airtime, advertising and transaction fees.

As internet/extranet access is targeted mainly to fixed business internet subscribers, but it is assumed that the service adoption will be slow until full multimedia Web/browsing with comparable quality and speed of fixed internet becomes available in 2004-2005, reaching the highest compounded average growth rate in subscriptions by 2010, as shown by a combination of tables 2 and 3. The security issues and the general complexity of the consumer base will cause mobile internet/extranet access services to lag consumer services by one year, delaying any significant commercial availability until 2002.

The demand forecast for MMS consumers uses SMS as an analogy, focusing on the teen age and the young adult market. It assumes messages per user will increase substantially. The service is used by about 20% of the total 3G subscribers.

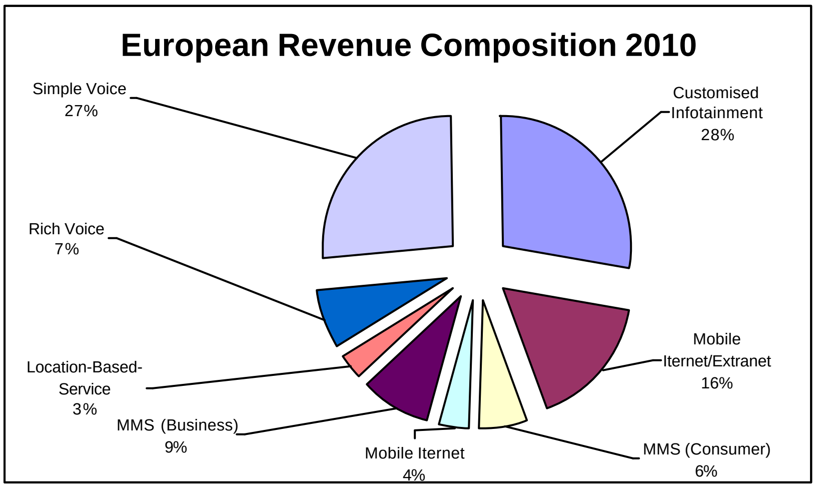
The typical mobile internet access user (consumer) is likely to be a current fixed internet user, who wants similar quality and functionality in a mobile service. This is a more closely targeted market, than the one found in customised infotainment users, comprising only 20% of the consumer 3G base by 2010.

Rich voice, which should be launched in 2004, by 2010 should reach the highest revenue growth rate. It can thus still be considered in the early stage of adoption, while **location based service** should begin in 2003 and has a slower growth rate by the end of period. **Simple voice service** is the only service, whose adoption starts by 2001, being nothing but a continuation of the 2G service.

3. EUROPEAN AND ITALIAN MARKET EVOLUTION.

Europe is a leading region of the world in the development of the 3G networks. Preliminary experience has already occurred, thanks to the WAP. Even though this system never took off the ground, a considerable show of interest by many users exists for these services. European mobile operators have already invested more that 100 billions of dollars in acquiring licenses for UMTS spectrum. The speed of deployment of 3G network is important to obtain a timely return on this type of investment. The forecast for countries in the European region assumes an earlier commercialisation date than in most countries in other regions. As shown in figure 1, over a half of the revenues comes from **customised infotainment** and **simple voice**, as in the worldwide case.

Figure 1. European 3G revenue composition 2010.



Source: UMTS Forum

Italian revenues, table 4, are derived using the market shares[5] provided by the UMTS Forum.

[5] UMTS report no. 9 and 13 report the Italian share of market revenue, for each service, in 2005 and 2010. We have assumed shares to be constant over the 4 preceding years. As a consequence, for each service, we estimated two different market shares, respectively for the period 2001-05 and 2006-10.

Table 4. Italian revenue for 3G services, 2001-2010
(millions of dollars and average growth rate, 2005-2010)
Source: UMTS Forum

Revenues	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	CAGR 2005-2010
Customised Infotainment	2.3	33.9	489.8	686.5	882.4	1507.2	2210.8	2316.3	2756.8	3615.7	32.6
Mobile Internet/ Extranet	0.0	43.3	264.8	259.3	346.8	609.0	928.7	1293.4	1790.5	2276.4	45.7
MMS (Consumer)	0.8	14.1	164.5	231.9	293.4	493.5	655.9	701.3	810.6	924.3	25.8
Mobile Internet	0.0	8.9	55.0	62.1	78.4	127.0	190.5	258.2	278.3	405.0	38.9
MMS (Business)	0.1	1.8	29.8	50.7	116.1	289.7	517.5	796.0	1066.7	1196.1	59.4
Location-Based-Service	0.0	1.4	53.2	110.1	140.7	166.0	241.2	275.8	316.4	401.2	23.3
Rich Voice	0.0	0.0	0.1	5.1	39.9	59.8	179.9	342.8	569.1	862.7	84.9
Simple Voice	3.9	40.9	470.8	618.2	794.9	1317.6	1916.2	1991.1	2360.6	2831.6	28.9
Total	7.1	144.3	1528.1	2023.9	2692.6	4569.8	6840.6	7975.0	9948.9	12513.0	36.0

The Italian total growth rate is lower that the corresponding worldwide rate of about 5 points. The greatest differences in growth rates are given by **customised infotainment, mobile internet access, location based service, rich and simple voice**.

4. LEGAL BACKGROUND AND REGULATION

Regulation of the right to use the spectrum is essential, to ensure that legitimate users obtain the required quantity and quality of radio communication services, without interfering with other legitimate users. This is done by using licences, frequency assignment, technical specifications, and legal enforcement to ensure compliance. Without the appropriate use of licensing, including frequency assignment, the radio spectrum would become unusable.

The licence has the twofold purpose of granting the holder a specific right for using the radio spectrum, and to place on her corresponding, specific obligations. Obligations for cellular operators may include maximum transmitter powers and sometimes requirements on the location of base stations. They may also include the requirement to provide radio coverage for a certain percentage of the population in a defined timeframe. Reference to a particular radio standard to be used (e.g. GSM or UMTS) can also be included.

The ultimate goal of issuing licences for radio services should be to facilitate access to the radio spectrum, of the appropriate quality for the widest range of services, while promoting the creation of wealth, competition and choice. In the particular case of UMTS, an additional goal is to help deliver the benefit of the coming wireless broadband multimedia services to the general public.

Practically all countries in the world have joined the ITU (International Telecommunication Union) and are bound by the Charter on Radio Regulations. These regulations establish that States must limit the number of frequencies and the spectrum used to the minimum essential, to provide the necessary services within an acceptable standard of quality. In using frequency bands for radio services, States must recognise that radio frequencies are natural resources available in limited supply. They must thus be used rationally, efficiently and economically, in such a way, that all countries may have equitable access to them.

4.1. THE ASSIGNMENT MECHANISM OF LICENSES.

Two approaches to license assignment have gained currency: in the traditional approach, licences are considered, especially with regard to spectrum, to give either the right to operate or the right to use. A newer approach is closer to the concept of property transfer. In the case of the spectrum, the State sells a portion or all its bandwidth to private buyers, who may, in turn, resell it to other economic players. This leads to the idea of a market value attached to the spectrum. This newer approach seems to be based on the notion that the spectrum is a property of the State, that can be transferred to other parties.

This approach, however, may be incompatible with international commitments. As noted earlier, according to the ITU radio regulations, States are bound to comply with restrictions in the use of radio frequencies in their territories. Various limitations apply for frequencies for different applications. In the newer approach, the spectrum is treated as land, which can be split up into parcels and sold or leased. The owner of a piece of land expects to use that land in any legal way that he chooses, as long as he does not interfere with his neighbours. The spectrum is not so easy to confine or to delineate. In fact, the attributes and properties of the spectrum are largely irreconcilable with the traditional concept of property. Spectrum users must consider the use of the spectrum in adjoining territories, before they decide their own use. Thus, for example, no State can rightfully claim to have the full ownership of a satellite frequency, to the same extend as land. Considerations such as these lead inevitably to the conclusion that the spectrum is not fully owned by any State. What a State owns is the right to use spectrum in its own territory, within the restrictions given by laws of nature, the obligations of the treaty on Radio Regulations and the rightful interest of the other countries.

The price paid for a spectrum license may be regarded as a rental or as an outright purchase of the State’s users rights. The latter notion is logically combined with a right to resell the licence. Any transfer of rights would need to be registered with the spectrum management authorities and the spectrum market would need to be regulated to avoid abuses. The discussion of spectrum pricing is thus likely to raise the question of privatisation. Any kind of transfer or leasing of spectrum rights can itself be represented as a kind of privatisation, but the logic can be taken further with the management of parts of the spectrum being put into private hands. The national authority then acts as a wholesaler, and possibly as a regulator of the kinds of intermediary which would retail spectrum rights to the final users of the spectrum. At present, most frequency licences throughout the world are non-transferable. If the right to transfer the use of sections of the spectrum are sold off to private operators, this could hinder the development of international co-operation, as States may no longer control the use of the spectrum and thus be unable to enter into international agreements.

Within the EU, the Licensing Directive (97/13/EC) provides the common framework for issuing licences for telecommunication services. For licence fees and spectrum pricing, the current licensing directive is not market oriented and indicates that recovery of the administration’s management costs should be the basic charging principle.

A possible exception to the administrative cost ceiling is the case of “the optimal use of scarce resources”, e.g. the spectrum. In this case, limited to individual licences (Art. 11.2 of the Licensing Directive), fees can be higher than what would be needed for mere cost recovering. However, Art. 11.2 establishes the following constraints: optimal use should not already be ensured by the burden of administrative costs, the spectrum fees may not go higher than that which can ensure an optimal use (“reflect the need”), innovation should be fostered, i.e. innovation should not be hampered by fees set too high, competition should be fostered, i.e. the pricing system should not result in reduced competition, e.g. by eliminating or hampering the viability of new entrants. Therefore, innovation and competition must be regarded as essential components of the "optimal use".

Other very important features of the licensing system, for our purposes, may be inferred from articles 4.4 and 9 of the aforementioned directive. They respectively establish that authorities must assign licenses with an adequate duration[6] and that where the "beneficiary of an individual license does not comply with a condition attached to the licence, the national regulatory authority may withdraw, amend or suspend the individual license or impose… specific measures..". Examples may include default of payment or failure to meet network roll-out obligations.

Individual countries in the EU have different systems for collecting fees and auctions have been used in some cases.

4.2. UMTS REGULATION IN ITALY.

In Italy, the licensing directive has basically been adopted by two distinct acts: the DPR 318/97, and the communication ministerial order 25/11/97.

The DPR 318/97, among other things, claims that:

Art 2.8

The number of individual licenses can be restricted only in the case of limited spectrum availability. Such limitations must respect proportionality, objectivity, non discrimination and transparency criteria.

Art. 6.13

The authority, in order to assign individual licenses, must adopt non discriminatory and transparent procedures, identical for all

[6] Avoiding "unreasonably short license duration".

candidates, unless there exists an objective reason to proceed differently.

Art 20.3

Individual license holders can directly provide investments and infrastructures for the working of the system.

Art 20.5

Individual license holders can use others' infrastructures and may, as well, provide common infrastructures, limitedly to the activities allowed by the license.

The ministerial order, as for the license assignments, states (Art. 8) some of the principles that the authority may require in the tendering procedure, such as: adequate technical credentials, a detailed business plan, for the next five years, which must comprehend: adequate financial and economic credentials, efficiency and quality of the service provided and a positive impact on employment and investments. The same article provides also principles to asses technical credentials.

The license assignment mechanism adopted in Italy has been implemented in two different phases. The first stage (a comparative bidding) sometimes called a beauty-contest, has involved the selection of the best applicants, according to pre-defined selection criteria (the qualification stage). The second stage is a competitive auction, sometimes called competitive bidding, during which licences have been awarded to the applicants that have made the highest bid.

A major risk with auctions is that the prices paid by licensees may become excessive. Market theory predicts that auctions will allocate bandwidth to those that value it the most and thus will make the most cost-efficient use of the spectrum. However, this does not necessarily mean that the spectrum will be used efficiently from the end-user's perspective. Another phenomenon that economic literature has highlighted to occur in an auction mechanism is the so called *winner's curse*. The winner, once known to be such, realises that the price bid is higher that the price offered by the other competitors. Thus the value attached to the good by the winner before winning, can be greater than the value he attaches after the discovery of other players' offer.

Italian competitors for the UMTS bandwidth initially were eight: **OMNITEL Pronto Italia**, **TIM**, **BLU, WIND, ANDALA, IPSE 2000 (DIX.IT e ALTANET), Tu-TLC Utilities (ATITALIA)** and **ANTHILL**. The last two failed to enter the first stage, and were not allowed to take part in the competitive bidding starting on the October 19th, 2000. In the second stage, the number of license bids were only five, as one of the original bidders (**BLU**) gave up. Five licenses were thus assigned, for a timeframe of 15 years from January 1st 2002 to December 31st, 2016. The final verdict was the following:

Table 5. Italian license winners and price paid
(Millions of euro)

OMNITEL Pronto Italia	2,448
IPSE 2000	2,443
WIND	2,427
ANDALA 3G	2,427
TIM	2,417

Source: V. Galasso Poletto(2001)

Many observers have considered the outcome of this auction rather anomalous, for two main reasons. First, final bid prices were lower than those realised either through the same mechanism (in the case of Germany) or through a beauty contest (France). Second, a group of solid firms, i.e. the **BLU** consortium, gave up when the price was only 10% higher than the basic price (2066 millions of euro).

These two observations rise several questions. Have the winners been harmed by the winner's curse? Was the initial price too high or too low? Can the license time length be considered adequate, complying with art 4.4 of the European directive? Has the possibility of withdrawing, amending or suspending the individual license, according to art. 9 of the European Directive, somehow affected the final result?

In the forthcoming sections we try to answer these and other questions, relying on a model developed by Knudsen and Scandizzo (1999) and Scandizzo-Ventura (2001 and 2002) on the optimal use of natural resources.

5. THE THEORETICAL BACKGROUND.

The original model was first developed as a theoretical and empirical model for the optimal use of natural resources, but it can readily be extended to any public good. In what follows, we briefly recall the set up of the model, in order to provide the basis for an empirical application to the Italian bid for the UMTS spectrum.

PAR. 5.1 THE BASIC MODEL

Assume the existence of a public good, generating an instantaneous constant flow of amenities, x, which, discounted at the riskless rate, ρ, yields a present value of x/ρ. The same public good, or resource, once developed, is supposed to generate a cash flow which evolves according to a geometric brownian motion of the type $dy_t = a y_t dt + y_t\ s\ dz_t$, where dz_t is a standard Wiener process with E (dz_t)=0 and Var(dz_t)= dt and α and σ are respectively the drift and the variance term of the process.

The public agent faces the decision of developing the resource directly, namely carrying out the investment herself, or granting a concession contract. The investment is supposed to be irreversible and the sunk cost is represented by I. Given this set up, we can regard the problem, as one in which the public agent owns an option to develop the resource directly or granting a concession contract to a private developer (concession holder). As a part of the concession contract, furthermore, the public agent may acquire, depending on the contract terms and the laws regulating contracts, the option to exit the contract, the so called "exit" or "expropriation option".

Formally, the public agent owns two options: one to enter the investment, the entry option, $F_0(y)$, and another to revoke the concession contract, the exit option, $F_1(y)$. Assuming that the dynamics of the risk contained in the cash flow, *dz*, can be spanned by existing assets, both options can be evaluated by applying the contingent claim evaluation (see Dixit-Pindyck, 1994) giving rise to the following second order partial differential equation:

(1) $$(r-d)yF_i^{'}(y)+\frac{s^2}{2}y^2F_i^{''}(y)-rF_i(y)=0$$

for i =0, 1; whose general solution is given by

(2) $$F_0(y)=A_1y^{b_1}+A_2y^{b_2}$$

(3) $$F_1(y)=B_1y^{b_1}+B_2y^{b_2}$$

where $b=\frac{1}{2}-\frac{(r-d)}{s^2}\pm\sqrt{\left[\left(\frac{r-d}{s^2}\right)-\frac{1}{2}\right]^2+\frac{2r}{s^2}}$

and $\delta=\mu-\alpha>0$, μ is the total expected rate of return, as suggested by the Capital Asset Pricing Model (CAPM), b_1 and b_2 are, respectively, the positive and negative root to the characteristic equation associated with equations (2) and (3). Since both options are increasing functions of the underlying variable, *y*, in order to satisfy the boundary condition $F_i(0)=0$, for i=0,1, both A_2 and B_2 must be equal to zero and we are left with either $F_0(y)$ or $F_1(y)$ as functions only of the positive root, b_1.

The alternative between the direct development and the concession contract, faced by the public agent, can be represented by the following value matching condition:

(4) $$\frac{x}{r}+F0(y_e)=\frac{y_e}{d}-\int_0^T y_e e^{-ds}ds+F1(y_e)+P_M$$

for t=0

The left hand side of equation (4) represents the value of the resource un-developed, given by the discounted value of the constant flow of amenities, x/r, plus the value of the entry option, $F_0(y)$. The right hand side accounts for the value of the resource once the concession contract has been granted, given by the expected cash flow from zero to infinity, y/d, minus the discounted cash flow gained by the concession holder over the concession time length, from zero to T, plus the minimum acceptable price to the public, P_M, and the value of the exit option, $F_1(y)$. The whole equation is evaluated at the optimum, y_e, the entry threshold. To figure out the optimal exercise point of the option, the so called entry threshold, we need another equation, the smooth pasting[7]condition , which is nothing but the derivative of the value matching at $y = y_e$.

Similarly, for the decision to exit, we must compare the value of keeping the concession alive to the value of the alternative, at a given point, y_u, given the appropriate value matching and smooth pasting conditions. Value matching for the exit point is formalised by equation (5):

$$(5) \quad y_u \int_t^{\infty} e^{-d(s-t)} ds - U = y_u \int_T^{\infty} e^{-d(s-t)} ds + F_1(y_u)$$

for $t \in (0;T)$.

The LHS of (5) contains the value of the concession in case the public agent decides to exercise the exit option, given by the value of the discounted cash flow from expropriation time, $t<T$, minus a sunk cost, U, which represents a sort of penalty paid by the public. The RHS, instead, contains the value of the concession contract in the opposite situation, when the public agent decides not to exercise the option, given by the discounted cash flow from T to infinity, plus the value of the exit option still

[7] The smooth pasting condition, in stochastic optimisation calculus, can be regarded as a First Order Condition. When dealing with options the second order condition is automatically satisfied by the convexity of the option (see Hull, 1997)

alive. Assume that the option is exercised at time t, when the value matching in (5) is verified. This means that the discounted values, both on the RHS and on the LHS of eq. (5), are evaluated at time t. In other words, we consider t as the moment at which future cash flows, from both alternatives, discounted at that date, are equivalent in value.

Equations (4) and (5), with the appropriate smooth pasting conditions, form two systems of two equations and two unknowns each. The solution to the entry system gives rise to a closed form solution to A_1, the constant included in the general solution (2) yet to be pinned down, and y_e, while the solution to the exit system gives rise to a closed form solution for B_1 and y_u.

PAR. 5.2 THE DECISION TO EXIT THE CONTRACT

For ease of reference, we report hereafter the exit equations

(6) $$B_1 y_u^{b1} = \frac{y_u}{d}\left(1 - e^{-d(T-t)}\right) - U$$ value matching

(7) $$B_1 y_u^{b1} = \frac{y_u}{db_1}\left(1 - e^{-d(T-t)}\right)$$ smooth pasting

Substituting (7) into (6), and setting t=0, as the time origin, we obtain the exit threshold:

(8) $$\frac{y_u}{d} \geq \frac{b}{(b-1)} \frac{U}{(1-e^{-dT})}$$

and substituting back into equation (6) we obtain the constant B_1, whose expression we omit for brevity.

Equation (8) can be read in the following way: the owner of the resource will find optimal to exit from the agreement when the value of net benefits, which is supposed to randomly fluctuate, hits a critical multiple of exit costs.

PAR. 5.3 THE DECISION TO ENTRY

From the entry side, the situation is slightly more complex. To compute the price paid for the contract, one cannot neglect the contractual counterpart: the potential concession holder. Obviously he too must find optimal to engage in the contract for which the following condition must be satisfied:

$$(9) \qquad \int_0^T y_c e^{-ds} ds - I - P_m - G(y_c) \geq 0$$

in plain English, the concession holder requires that the maximum affordable price, P_m, be not greater than the cash flow gained over the concession time length, minus the investment cost, I, minus the value of a call option, *G(y)*, which he implicitly or explicitly charges, as a sort of insurance for the expropriation risk borne. Similarly to equations (4) and (5), equation (10) can be regarded as a value matching condition and exploited to determine the value of the option. Since the expropriation becomes more likely for higher values of the underlying, y, we need also $G(\bullet)$ to be an increasing function of y, hence its value is again a function only of the positive root of the characteristic equation, b_1.

It is now possible to determine P_m (combining (9) with its smooth pasting condition), the maximum price the concession holder is willing to pay to enter a concession contract of time length T, for a given value of *y:*

$$(10) \qquad P_m \leq \frac{y}{d}\left(1 - e^{-dT}\right)q - I$$

where $q \equiv \dfrac{b_1 - 1}{b_1}$

On one hand, the owner of the resource must compare the value of the concession contract to the value of keeping the resource undeveloped, but on the other hand, he must also take into account the possibility to develop the resource directly tackling the investment. To consider this double alternative, we must write out separately two value matching, and relative smooth pasting conditions, accounting for both alternatives and then compare them, to work out under what conditions the concession is preferable.

As already mentioned, the alternative between preservation and concession is given by equation (4) and the related smooth pasting condition, that we report hereafter for ease of reference :

$$\frac{x}{r} + (A_1 - B_1) y_e^{b1} = \frac{y_e}{d} e^{-dT} + P_M$$ entry value matching

$$(A_1 - B_1) y_e^{b1} = \frac{y_e}{db_1} e^{-dT}$$ smooth pasting

Appropriately arranging and solving for the price we get

(11) $$P_M \geq \frac{x}{r} - \frac{y}{d} e^{-dT} q$$

where P_M represents, for each admissible value of the expected cash flow, y, the minimum acceptable price to the public agent.

The condition for choosing direct investment over preservation is obtained in Knudsen-Scandizzo (1999) and can be stated as follows:

$$\frac{y}{d} q \geq \frac{x}{r} + I \ .$$

It is now possible to write the condition, in terms of P_M, under which, for the same value of y, the concession is preferable to direct development

(12) $\frac{y}{d}e^{-dT}q - \frac{x}{r} + P_M \geq \frac{y}{d}q - \left(\frac{x}{r} + I\right)$ or

(13) $\frac{y}{d} \leq \frac{P_M + I}{1 - e^{-dT}}\frac{1}{q}$

Substituting the value of y from equation (11) and simplifying we end up with an expression for P_M independent of y

(14) $P_M \geq (1 - e^{-dT})\frac{x}{r} - e^{-dT} I$

In order to make the concession contract feasible, it is clear that P_m must be greater or equal to P_M, P_m ³ P_M (eq.(10) ≥ eq.(14)), namely in terms of y, the following condition must hold:

(15) $\frac{y_e}{d} \geq \frac{b_1}{b_1 - 1}\left(\frac{x}{r} + I\right)$

which indicates the entry threshold as the value of y that is at or above an appropriate multiple of preservation and investment costs.

PAR. 5.4 PRICE AND TIME LENGH

Let us turn now to the price to which the bargaining process leads. Assuming that the parties hold equal bargaining power, we determine the Nash price maximizing the product of the players' net payoffs

$$\underset{P}{MAX}\left[\frac{y}{d}(1 - e^{-dT})\frac{b_1 - 1}{b_1} - I - P\right]\left[P - (1 - e^{-dT})\frac{x}{r} + e^{-dT} I\right]$$

Thus, the concession price is given by the arithmetic mean of the two limiting prices, respectively the maximum and minimum required by the concession holder and by the owner of the resource:

$$P=\frac{1}{2}\left[\frac{y}{d}\frac{b-1}{b}(1-e^{-dT})-I\right]+\frac{1}{2}\left[(1-e^{-dT})\frac{x}{r}-Ie^{-dT}\right] \quad .$$

If we determine the value of P at the entry point, y_e, we obtain the reduced form of the equilibrium price as:

$$P_R=(1-e^{-dT})\frac{x}{r}-e^{-dT}I$$

and for any value of P we can solve for the optimal time length, T

$$T=\frac{1}{d}\ln\left(\frac{\frac{x}{r}+I}{\frac{x}{r}-P}\right)$$

In sum, we have started from three value matching conditions, two of which are faced by the public: entry and exit, and one faced by the concession holder, and we have managed to determine in closed form solution the following variables: y_e, y_u, P_M, P_m, P_R and T.

The model, developed so far, is a basic logical structure, that can be readily adapted to special cases. The results can be obtained in the presence or absence of the exit option (revocable and not revocable case) and are applicable to different cases of concession contracts: B.O.T. (Build Operate and Transfer), B.O.O.T. (Build Operate Own and Transfer) and B.O.O. (Build Operate and Own).

Thus far, we have contemplated the case of a revocable B.O.T., i.e. the owner of the resource has the faculty to exercise the expropriation option prior to T, the time to transfer the investment back from the concession holder to the owner. If one wants to contemplate the case of absence of such a faculty, namely the non revocable case, all one needs to do is to remove $F_1(y)$ in equation (4) and the counterpart $G(y)$ in equation (9) and repeat the same steps followed in the basic model to get different formulae of same variables[8], y_e, P_M, P_m, P_R and T.

Similarly, to capture the basic feature of B.O.O.T, one can simply assume that the expropriation option expires at the time the ownership of the resource is transferred from the public to the concession holder, at t with $t<t<T$ and follow again the same steps of the basic model. Finally, for a B.O.O. all one needs to do is to replace the expiration day of the concession contract, *T*, by infinity and follow the usual procedures.

The solutions for all possible combinations of the three contracts, B.O.T, B.O.O.T and B.O.O., under both context, revocable and non revocable, are reported in Table 6. For proofs, and detailed comments and algebraic treatments, we refer the reader to Scandizzo-Ventura (2001 and 2002).

[8] Obviously in this case the exit conditions vanishes.

Table 6. Theoretical results for some variables of interest.

Variable to be determined	B.O.T. and B.O.O.T (revocable case)	B.O.T. and B.O.O.T (not revocable)	B.O.O (revocable)	B.O.O (not revocable)
Entry threshold	$y_e \geq \frac{db}{b-1}\left(\frac{x}{r}+I\right)$	$y_e \geq d\left(\frac{x}{r}+I\right)$	$y_e \geq \frac{db}{b-1}\left(\frac{x}{r}+I\right)$	$y_e \geq d\left(\frac{x}{r}+I\right)$
Maximum price	$P_m \leq \frac{y_c}{db}\left(1-e^{-dT}\right)(b-1)-I$	$P_m \leq \frac{y_c}{d}\left(1-e^{-dT}\right)-I$	$P_m \leq \frac{y_c}{db}(b-1)-I$	$P_m \leq \frac{y_c}{d}-I$
Minimum Price	$P_M \geq (1-e^{-dT})\frac{x}{r}-e^{-dT}I$	$P_M \geq (1-e^{-dT})\frac{x}{r}-e^{-dT}I$	$P_M \geq \frac{x}{r}$	$P_M \geq \frac{x}{r}$

Equilibrium price	$P=\frac{1}{2}\left[\frac{y}{d}\frac{b-1}{b}(1-e^{-dT})-I\right]+\frac{1}{2}\left[(1-e^{-dT})\frac{x}{r}-Ie^{-dT}\right]$	$P=\frac{1}{2}\left[\frac{y}{d}(1-e^{-dT})-I\right]+\frac{1}{2}\left[(1-e^{-dT})\frac{x}{r}-Ie^{-dT}\right]$	$P=\frac{1}{2}\left(\frac{x}{r}+\frac{y}{db}(b-1)-I\right)$	$P=\frac{1}{2}\left(\frac{x}{r}+\frac{y}{db}(b-1)-I\right)$
Concession time length	$T=\frac{1}{d}\ln\left[\frac{-\left(\frac{y}{d}\frac{b-1}{b}+I+\frac{x}{r}\right)}{2P+I-\frac{y}{d}\frac{b-1}{b}-\frac{x}{r}}\right]$	$T=\frac{1}{d}\ln\left[\frac{-\left(\frac{y}{d}+I+\frac{x}{r}\right)}{2P+I-\frac{y}{d}-\frac{x}{r}}\right]$	Infinity	Infinity

Source: Scandizzo-Ventura (2001)

In the table, one can read in each column the different solutions to the key variables of the theoretical model, while in each row one can compare the different results for the same variable under different contracts and contexts. In the first row, the value of the entry threshold, under the different alternatives: B.O.T., B.O.O.T. and B.O.O., revocable and not revocable, are reported.

B.O.T and B.O.OT are formally equivalent in any case and the entry threshold also coincides to the B.O.O. case, respectively in the revocable and not revocable case. The fundamental difference of the results in the two contexts, are the presence or absence of the factor $\frac{b}{b-1}$ accounting for the risk, which is obviously missing in the case of absence of expropriation threat.

6. EMPIRICAL RESULTS

Table 7 summarises our results on the application of the model to the behaviour of **TIM**, one of the participants and winners of the bid for the Italian UMTS spectrum. As an exercise, and to derive some useful insights, we have applied the model to all of the possible cases and possible contracts, despite the fact that the contract stipulated on November 2000 can be regarded as a revocable B.O.T.. The presence of the exit option can be inferred from articles 4.4 and 9 of the Licensing Directive (97/13/EC), providing that the common European framework be used for issuing licences for telecommunications services. Data on **TIM**'s cash flow and investment costs are taken from the Quarterly Reports available on the web site.

Table 7. Empirical results for **TIM**
(millions of euro and quarters)

Variable to be determined	B.O.T. and B.O.O. (revocable case)	B.O.T. and B.O.O. (not revocable)	B.O.O (revocable)	B.O.O (not revocable)
Entry threshold	642	113	96	17
Maximum price	2630	20536	41311	255087
Equilibrium price	2348	18334	21688	128577
Minimum price	2066	2066	2066	2066
Concession time length	61	17	infinity	infinity
Bargaining power (θ)	0.38	0.98	0.99	1.0

Source: based on **TIM** Quarterly Reports and Datastream.

When the bid took place, information available in November 2000 revealed a current value of the cash flow of 700 millions of Euro[9]. This has been the value at which the company has been willing to enter the investment. Because at the same time it was also the value that made the public agent willing to grant the license, it can be regarded as the "true" entry threshold. We thus want to inquire, using our model, whether the investment options held by both agents were exercised at the money or out of the money. For that purpose we have tabulated the empirical counterpart of the entry threshold (first line table 7).

As it immediately appears, there is not a large gap between the estimated or “empirical”[10] and the observed or “actual” threshold, for the revocable case. While it is much larger

[9] **TIM** Investor Relations, third quarter 2000, p.22.

[10] We refer to as "empirical" to indicate the crude estimate worked out through by applying the model to data, while we call "actual" the value that really occurred.

for the other cases, the actual is more than six times greater than the empirical, for the revocable case, and even larger for the B.O.O. cases.

This differences suggest that the options held by both investors were into the money. Moreover, it confirms the firms' attitude to require high return rates, before entering an irreversible investment in an uncertain environment, much higher than what suggested by the NPV practise, in accordance with the real option paradigm.

The equilibrium price reported in Table 7, on the other hand, can be interpreted as the price that, under the assumptions of the model, would have prevailed at the actual value of the cash flow. A higher price paid[11], as compared to the theoretical equilibrium price, generates two immediate consequences. First, for the actual value of the cash flow, the concession time length should have been slightly longer, sixty-one instead of sixty quarters. Secondly, we can infer that the implicit bargaining power held by the parties in the bargaining round was unequal, 0.38 for **TIM** and 0.62 for the public sector. The situation is even more unbalanced in the other cases, but with changed sign.

7. CONCLUDING REMARKS

Within the context of the dynamics of the market for telecommunications and the new generation of mobile services, this article has presented an approach to evaluate the terms of concession contracts. As an illustration of the implications of the model, we applied the theoretical results obtained to the evaluation of **TIM**'s contractual position in the Italian UMTS license assignment.

[11] The actual price paid amounts to 2,417 millions of euro, see Table 5.

Comparing the results displayed in Table 7, it appears that the presence of the expropriation option may have attenuated **TIM**'s power and so does the presence of a fixed term of the contract. However, the empirical application of Scandizzo-Ventura (2001 and 2002) model has not confirmed the widespread opinion that **TIM** has played a dominant role in the bid, holding 38% of the bargaining power, and that counterpart revenues earned by the public agent have been excessively low. The price paid by **TIM** in the license assignment could have been slightly higher (up to 2,630 millions of euro instead of 2,417) and for the actual price paid, the concession time length should have been slightly longer.

In order to attempt to account for by the gap between the empirical and actual price paid, we have worked out the implicit volatility and the implicit drift of the underlying process, i.e. the values of sigma and alpha that make the empirical equilibrium price equal to the actual one. As can be shown by deriving eq. (10) with respect to sigma, in a more volatile context the concession holder, willingness to pay is lower. In our case, simulations show that, in order to make the two prices converge, the variance term is required to decrease form 5.28 to 4.77%. In other words, an increase of 2.9% of the willingness to pay (form 2,360 to 2,417 millions of Euro) can be obtained through a decrease of 9.7% of the volatility term. This seems to reveal a relatively steep P_m curve with respect to sigma, which in turn, can be read as a condition of strong "risk aversion".

Simulations also show very high sensitivity to change in the drift term. A very little change in the value of alpha, from 4.02% to 4.01%, suffices to make the two prices converge. However, in this case one should be cautious in interpreting this high sensitivity of price to alpha. The simulated value suffers form the fact that the externality, x/r, has been evaluated by difference, namely subtracting $Ie^{-\delta T}$ from the known initial value of the bid, 2,066. In this way, a change in the value of the drift is followed by a change in the value of initial price . In other words, working out the implicit alpha, one must either work out a different initial price, given the estimate of the externality, or allow for a different value of the externality, given the initial price.

While these results are tentative and are designed only to illustrate the potential use of an appropriate evaluation model, they do suggest that, in securing the UMTS bid, **TIM** may have suffered the winner's curse.

APPENDIX.

Estimation of the mean and variance terms of the process

To estimate the mean and the standard deviation terms of the process followed by the cash flow we have run the following regression:

$$\ln(y_t) = c + \beta t + u_t \qquad (1)$$

where $\ln(y_t)$ is the natural log of the Tim cash flow at time t, c represents the intercept and u_t is a white noise process.

Actually, this regression comes form some simple algebraic considerations. Starting from the standard definition of the GBM we have that

$$\int \frac{dy_t}{y_t} = \int a\,dt + \int s\,dz_t$$

the integral on the right-hand side cannot be solved as $\ln(y_t)$, as in the ordinary calculus, but by using the solution method for stochastic integrals.

The first integral on the right-hand side does not contain any random term, it can be calculated in the standard way, the second integral does contain a random term, but the coefficient of dz_t is a time-invariant constant. Thus we have

$$\int \frac{dy_t}{y_t} = a\,dt + s dz_t$$

any solution to the Stochastic Differential Equation (SDE) must satisfy this integral equation. In this particular case let us consider the candidate

$$y_t = y_0 \exp\left\{\left(a - \frac{s^2}{2}\right)t + s z_t\right\}$$

to verify that this is indeed a solution let us use the Ito's lemma to calculate the stochastic differential

$$dy_t = y_t\left[\left(a - \frac{s^2}{2}\right)dt + s dz_t + \frac{s^2}{2}dt\right]$$

simplifying and rearranging we end up with the usual expression for a Geometric Brownian Motion.

$$\frac{dy_t}{dy_t} = a\,dt + s\,dz_t\ .$$

Therefore, the drift and the variance term of the process can be estimated running regression (1) where β has been set to be equal to $\left(a - \frac{s^2}{2}\right)$ and the variance term is given by the SE of the regression.

In a much more simple way, this procedure is equivalent to working out the mean and variance of the process $d\ln(y_t)$ to get respectively $\left(a - \frac{s^2}{2}\right)dt$ and σ^2.

REFERENCES

Candeo M. (2001), "Il processo di liberalizzazione e di regolamentazione delle telecomunicazioni in Italia" July, unpublished dissertation

Dixit A.K. Pindyck R.S. (1994), Investment Under Uncertainty. *Princeton University Press, Princeton*

Galasso Poletto V. (2001), "La politica della concorrenza in Europa: il mercato delle telecomunicazioni" March, unpublished dissertation

Hull J.C. (1997), Options, Futures and Other Derivatives. *Prentice Hall*, Third Ed.s

Knudsen O.K. and Scandizzo P.L (*1999*), *The cost benefit analysis of natural resource project*, World Bank w.p. no 390. Paper presented at the International Conference "The Shape of the Coming Agricultural Biotechnology Transformation: Strategic Investment and Policy Approaches From an Economic Perspective", Roma-Ravello, giugno.

Scandizzo, P.L. and Ventura M. (2001), "Uso ottimale delle risorse naturali: project financing e valore d'opzione" *w.p. Sichelgaita*, n. 25.

Scandizzo, P.L. and Ventura M. (2002), "Uso ottimale delle risorse pubbliche: project financing e valore d'opzione" *w.p.*

TIM: "Quartely Investor Relations", from First Semester '98 to First Semester '01. Available on the web site http://www.investor.tim.it

UMTS Forum, "Report" no. 1, 3, 4, 8, 9, 10, 13. Available on the web site http://www.umts-forum.org