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BROADCAST MOBILE TELEVISION SERVICE IN FINLAND: A TECHNO-ECONOMIC ANALYSIS

Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Engineering

Espoo, 29 March 2007

Supervisor: Professor Heikki Hämmäinen
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HELSINKI UNIVERSITY OF TECHNOLOGY	ABSTRACT OF MASTER'S THESIS

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A commercial DVB-H mobile TV spectrum licence was awarded to Digita Oy in Finland in March 2006. One year later, the network infrastructure is operational but there are no service operators or DVB-H enabled handsets available to the public. One possible reason for the current situation is the uncertainty concerning best business models for both mobile operators and broadcasters. This uncertainty surrounding the future of the DVB-H business sparked the motivation and interest for conducting this study. The purpose of this study is to identify plausible DVB-H mobile TV business models, and to evaluate and rank such models according to their economic performance prospects. We chose techno-economic analysis as the research method, and constructed a quantitative model of the DVB-H mobile TV business ecosystem, enabling the evaluation of potential cash flows with different parameters. We collected data for the modelling through conducting a literature review as well as a comprehensive set of interviews with leading industry experts.

The results of the techno-economic analysis support the dominant expectations of the interviewed experts. DVB-H mobile TV services are not likely to become a major source of revenues, let alone the next 'killer application', for mobile operators or broadcasters in Finland. This study indicates that the least risky and easiest-to-implement business model for a mobile operator appears to be co-operating with broadcasters to bring the new services to market. According to the proposed business model, broadcasters would take care of attaining the required DVB-H network capacity as well as provide the programming, whilst mobile operators would take care of the sales and marketing of the new services to consumers. Yet the foremost value creation potential for mobile operators and broadcasters appears to be in also performing the other party's role (a mobile operator becoming a DVB-H broadcaster, or a broadcaster selling DVB-H services directly to consumers, bypassing mobile operators). These models are, however, also associated with considerably higher risks. To conclude, the results of this study indicate a conflict of interests between the two key parties regarding the sharing of costs and potential revenues.

Mobile operators, broadcasters, and other parties interested in DVB-H mobile TV business, can use the results of this study for reference and comparison with their own calculations. More importantly, the results can provide avenues for new discussions between the parties. In addition, this study paves ground for further research on potential business models concerning the commercialisation of the DVB-H mobile TV service technology.

Keywords: DVB-H, mobile television, techno-economic analysis, business model.

TEKNILLINEN KORKEAKOULU — DIPLOMITYÖN TIIVISTELMÄ

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Työn nimi: Matkaviestimillä vastaanotettavat joukkoviestintäpalvelut Suomessa: teknis-taloudellinen analyysi.

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Kaupallinen DVB-H-tekniikkaan perustuva, matkaviestimillä vastaanotettaville digitaalisille joukkoviestintäpalveluille (DVB-H-mobiilitelevisio) tarkoitettu verkkotoimilupa myönnettiin Digita Oy:lle Suomessa maaliskuussa 2006. Vuotta myöhemmin verkko on toiminnassa, mutta Suomessa ei toimi palveluoperaattoreita eikä yleisölle ole myynnissä DVB-H-vastaanottimia. Yksi mahdollinen syy nykytilanteeseen on parhaisiin liiketoimintamalleihin liittyvä epävarmuus matkaviestinoperaattoreiden ja TV-yhtiöiden kannalta. Tämä DVB-H-liiketoiminnan tulevaisuutta koskeva epävarmuus synnytti motivaation ja kiinnostuksen tämän tutkimuksen tekemiseen. Tämän tutkimuksen tarkoituksena on tunnistaa DVB-H-mobiilitelevision todennäköiset liiketoimintamallit ja järjestää ne taloudellisen suorituskyvyn mukaan. Valitsimme tutkimusmenetelmäksi teknis-taloudellisen analyysin, ja rakensimme DVB-H-mobiilitelevision liiketoimintaekosysteemistä kvantitatiivisen mallin, joka mahdollistaa potentiaalisten kassavirtojen arvioinnin eri parametrein. Keräsimme lähtötiedot mallia varten kirjallisuuskatsauksella sekä haastattelemalla kattavan määrän alan johtavia asiantuntijoita.

Teknis-taloudellisen analyysin tulokset tukevat haastateltujen asiantuntijoiden vallitsevia odotuksia: DVB-H-palvelut eivät todennäköisesti tule olemaan suuri tulonlähde tai seuraava ”tappajasovellus” matkaviestinoperaattoreille tai TV-yhtiöille Suomessa. Tulosten mukaan matkaviestinoperaattorin kannalta riskittömin liiketoimintamalli olisi yhteistoiminta TV-yhtiöiden kanssa palvelujen tuomiseksi markkinoille. Tässä mallissa TV-yhtiöt hankkisivat lähetyskapasiteetin ja ohjelmistosisällön, ja matkaviestinoperaattori hoitaisi palvelujen myynnin ja markkinoinnin kuluttajille. Kuitenkin suurin potentiaali arvon luomiselle sekä matkaviestinoperaattorin että TV-yhtiön kannalta näyttäisi olevan toistensa roolin omaksumisessa (matkaviestinoperaattorista tulisi DVB-H-TV-yhtiö, tai TV-yhtiö myisi DVB-H-palveluja suoraan kuluttajille ohittaen matkaviestinoperaattorit). Näihin malleihin kuitenkin liittyy myös huomattavasti korkeammat riskit. Yhteenvetona tulokset näyttävät intressiristiriidan näiden kahden avainosapuolen välillä liittyen kustannusten ja mahdollisten tuottojen jakamiseen.

Matkaviestinoperaattorit, TV-yhtiöt ja muut DVB-H-mobiilitelevisiosta kiinnostuneet osapuolet voivat käyttää tämän tutkimuksen tuloksia vertailukohtana omille tutkimuksilleen. Mikä tärkeämpää, tulokset voivat mahdollistaa uusia keskusteluja osapuolten välillä. Lisäksi tämä diplomityö pohjustaa jatkotutkimuksia DVB-H-tekniikan kaupallistamisen liiketoimintamalleihin.

Avainsanat: DVB-H, mobiilitelevisio, teknis-taloudellinen analyysi, liiketoimintamalli.

Preface

This thesis concludes my studies toward the degree of Master of Science in engineering. The work for this thesis has been carried out at TKK Networking Laboratory and as a part of the national COIN research project.

I want to take this opportunity to thank my instructor Timo Smura for his guidance and comments throughout the research and writing process. Special thanks go also to my supervisor, Professor Heikki Hämmäinen, for providing me his endless insight and support.

I want to thank also Eino Kivisaari for providing new viewpoints for my research and for sharing his DVB-H expertise. In addition, I want to thank my colleagues in the networking business team for their support: Annukka, Antero, Hannu, Kim, Mathias, Mikko, Renjish, and Timo N.

My sincere thanks go also to my dear Hanna and Rami for patience during the long evenings and weekends spent writing this thesis, and to my family for their support during my studies.

Finally, I would like to thank the brilliant experts I had the chance to interview for sharing their time and knowledge. This thesis would not have been possible without their valuable contribution.

Helsinki, 29 March 2007.

Tuukka Autio

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Key concepts

Broadcasting is a means of communication, especially the transmission of TV and radio programmes to all viewers or listeners in the network coverage area, as opposed to **unicasting**, which is the transmission of information separately to an individual viewer.

Channel is a portion of a frequency spectrum that is set aside for a specific purpose, for example, the broadcasting of a television or radio signal.

DVB-H is a version of the European digital terrestrial television standard DVB-T, enhanced for mobile handheld reception.

IP Datacast over DVB-H (IPDC/DVB-H) is an Internet Protocol enabled end-to-end broadcast system for the delivery of digital services to mobile handheld devices. The system uses a unidirectional broadcast path and can be combined with a bi-directional return path.

Mobile TV is television service for mobile devices using either a terrestrial or satellite broadcast network, or a cellular (mobile) network as the transmission method.

Multiplex is a set of digital TV and radio services that are mixed together into one broadcast signal. Multiplex transmission allows the reception of multiple services on a single frequency range.

Techno-economics is a branch of science focusing on the economics of new technologies and business models.

Smartphone is a mobile phone, which runs a commercial operating system (such as Symbian, Windows Mobile, Linux, or OS X) and allows installing additional native applications.

Simulcasting is the simultaneous transmission of the same television or radio signal or programme over two or more separate transmission networks.

Single Frequency Network (SFN) is a regional broadcasting network, in which several transmitters broadcast the same signal using the same frequency channel.

Abbreviations

16QAM	16-state Quadrature Amplitude Modulation
3G	Third-generation (mobile phone technology)
CMLA	Content Management Licence Administrator
COIN	Dynamics of COmpetition and INnovation in the converging Internet and mobile networks.
DAB	Digital Audio Broadcasting
DCF	Discounted Cash Flow
DVB-H	Digital Video Broadcasting Handheld
DVB-T	Digital Video Broadcasting Terrestrial.
ECOSYS	Techno-ECOnomics of integrated communication SYStems and services.
GSM	Global System for Mobile Communications
IPDC	IP Datacast, Internet Protocol Datacast.
IPDC/DVB-H	Internet Protocol Datacast over Digital Video Broadcasting Handheld
MMS	Multimedia Messaging Service
NPV	Net Present Value
OFDM	Orthogonal Frequency Division Multiplexing
S-DMB	Satellite Digital Multimedia Broadcasting
SFN	Single Frequency Network.
SMP	Significant Market Power
SMS	Short Message Service
T-DMB	Terrestrial Digital Multimedia Broadcasting
TV	Television
WCDMA	Wideband Code Division Multiple Access
WTP	Willingness to pay
YLE	Yleisradio Oy. Finnish Broadcasting Company.

1 Introduction

1.1 Background

On 23 March 2006, following a beauty contest, Finnish government awarded a commercial DVB-H spectrum licence to Digita Oy, a broadcast network operator. This 20-year licence permits Digita to build and operate a new network based on DVB-H technology. The DVB-H standard has been designed for distributing digital broadcast mobile TV services.

Mobile TV, made possible by the convergence of media and telecommunications industries as well as the convergence in consumer electronics, was one of the most hyped new mobile services in Europe in 2006 (Gartner, Inc. 2006). The advertised key features of mobile TV are personalisation, interactivity, and most importantly, 'placeshifting', i.e., the ability to watch ones favourite TV programming while on the go.

DVB-H technology has been strongly pushed in Europe by the mobile phone manufacturer Nokia. Italy and Finland are so far the only European countries with live DVB-H networks, but others are expected to follow suit as soon as spectrum becomes available.

In Finland, Digita proceeded to launch its DVB-H network in the capital region and in the cities of Turku and Oulu on 1 December 2006, although there were no handsets available to the public. The initial population coverage of the network was approximately 25%, and Digita has agreed to expand it to at least 40% by the end of 2007.

However, even now that the network is operational in Finland, there remains uncertainty concerning the shape of the emerging mobile TV business ecosystem and the business models that will create the most value for service operators. This uncertainty sparked the motivation and interest for conducting this study, as we perceive the industry's ability to construct a viable business ecosystem around mobile TV as a key factor in delivering compelling services to the consumers.

In this thesis, we evaluate the DVB-H mobile TV service business case in Finland by applying a techno-economic modelling approach, supported by expert interviews and a literature review. By analysing different business models in simulated market conditions, we aim to identify and quantify new cash flows potentially generated by mobile TV services. We can then rank the different business models according to their economic performance. The analysis process also enables us to test the applicability of the chosen techno-economic methodology in such context.

This thesis is a part of a two-year national research project, *Dynamics of COmpetition and INnovation in the Converging Internet and Mobile Networks* (COIN)[1], in which the Networking Laboratory of Helsinki University of Technology (TKK) is participating along with a number of leading industry partners.

1.2 Research problem

The uncertainty surrounding the emerging mobile TV business ecosystem and business models creates the research problem that this thesis aims to address: "Which service operator business models would create the most value in simulated market conditions, and which factors affect the value the most?"

We regard the significance of the research problem as notable and topical, since there are not many public studies focusing on the service side of mobile TV, and practically none dealing with Finland. Moreover, mobile service operators and broadcasters have been quite silent about their plans for service operations, perhaps partly because of ongoing copyright negotiations, but also potentially because of the uncertainties regarding the best business models.

Our study then provides a public and impartial assessment of the business case, enabling further, perhaps more delicate studies on the various aspects of the business ecosystem and business models. Moreover, our study can also enable new discussions between different parties.

[1] COIN project website: http://www.netlab.tkk.fi/tutkimus/coin/

Through conducting the business case analysis, we can also evaluate the applicability of the used techno-economic methodology in addressing such a problem.

1.3 Objectives of thesis

The primary objective of this thesis is to

- construct a techno-economic model of DVB-H broadcast mobile TV service business ecosystem in Finland,
- identify plausible DVB-H mobile TV business models for mobile operators and broadcasters, and
- evaluate and rank such business models according to their economic performance prospects.

The secondary objective of this thesis is to gain more understanding of the technical, economic, and regulative issues involved in the DVB-H service business, and to develop further the means of conducting a techno-economic analysis of a service business case.

1.4 Scope of research

We restrict the scope of research with the following three limitations. First, we limit the scope of research regionally to Finland. This implies that we study the Finnish mobile TV service industry, regulation, and market conditions. Related EU regulation is included in the scope as well. Other regions and markets are out of the scope.

Second, we limit the scope to the actors directly or closely related with the service operation. This means that we study mainly mobile operators and broadcasters, and to some degree content provision and broadcast network operation. Infrastructure vendors, application vendors, and such are out of the scope.

Third, we limit the scope to mobile phones as the service reception device, IPDC/DVB-H as the broadcast network technology, and GPRS/WCDMA as the return path technology. Other technical implementations, e.g. DAB-based networks or WLAN return path, are out of the scope.

1.5 Research methods

The research methods used in this study are literature review, semi-structured expert interviews, and techno-economic analysis.

In the literature review, we address the business, regulative, and technical issues concerning mobile TV. There are not many specific literature sources covering the mobile TV business models, as the first commercial mobile TV networks have only recently launched around the world. We therefore apply general economic theory about the sales of information goods as well as findings from mobile service usage studies and mobile TV pilot studies.

For regulative information, we resort primarily to information from Ministry of Transport and Communications, and Finnish Communications Regulative Authority (FICORA). We cover also related law, especially the Communications Market Act of 2003 and its amendments.

In the semi-structured interviews, we gather expert opinions from different sides of the ecosystem. The interview questions address the emerging services, business models, and revenue sharing. The interviewees come from, in alphabetical order, Digi TV Plus Oy, Digita Oy, Elisa Oyj, MTV Interactive Oy, Nokia Oyj, SWelcom Oy, Telecommunications Software and Multimedia Laboratory of Helsinki University of Technology (TKK), and TeliaSonera Oyj. By a common wish we list the interviewed experts at the end of the thesis but do not quote them by name or company, as the opinions of the interviewees are personal and do not necessarily present those of their employers.

For the techno-economic analysis, we use a Microsoft Excel based ECOSYS tool. The tool and analysis methodology by the same name have been developed in several consecutive EU research projects. We base the scenarios and other inputs for the techno-economic model on the literature review, the expert interviews, and our prior knowledge of networking business.

1.6 Structure of thesis

We organise this thesis in chapters so that we begin by presenting the techno-economic methodology in chapter two. The chapter discusses the inputs and outputs of techno-economic analysis, and its strengths and weaknesses. The chapter also presents the ECOSYS tool used in this study.

In chapter three, we describe the construction of the actual techno-economic model of the mobile TV service business case in detail. The chapter includes a presentation of the generic business ecosystem of mobile TV in Finland, and the various service operator models we study, as well as a systematic description of different factors and assumptions in the model.

In chapter four, we present the numeric results of the techno-economic analysis. The chapter includes the value of the business case for different types of service operators and different business models, as well as a sensitivity analysis to identify which factors affect the value the most.

In chapter five, we sum up our findings and draw conclusions of the business case. The chapter includes an interpretation and assessment of the results, as well as evaluation of reliability and validity of the study. The chapter also discusses possible exploitation of results and recommends items for future research.

In chapter six, we discuss the relationship between WCDMA streaming mobile TV and DVB-H mobile TV, as well as the general outlook of DVB-H services in Finland and on a global scale.

2 Overview of techno-economic methodology

In this chapter, we give an overview of the techno-economic research methodology we use in this thesis. We describe the analysis inputs and outputs, discuss the interpretation of the outputs, and present the ECOSYS tool that we use for the quantitative analysis.

2.1 Techno-economic analysis

Techno-economics is a branch of science that focuses on analysing the economic aspects of new technologies or innovations and associated business models. According to Hull, Walsh, Green, and McMeekin (1999), Techno-economic study can involve the examination and description of dynamic relationships amongst various actors, and flow of intermediaries (money, contracts, etc.) required for the progress of a specific innovation (techno-economic networks), as well as long-term fluctuations in economic growth and links with technical change (techno-economic paradigms). Techno-economics thus allows the adoption of an analytic framework which is neither totally micro and case-study based, nor totally macro and policy-oriented.

For the purposes of this thesis, we can define techno-economic analysis as a quantitative analysis seeking to determine the economic feasibility of innovations and new services in a certain market setting, as well as a qualitative analysis for identifying and describing the required business roles and interactions.

Much of the terminology and methodology we use in this thesis has been developed during the last 16 years under the framework programmes of the European Union. The original methodology was introduced under the first framework programme for communications research, RACE I[2]. The work has continued under

[2] Research for Advanced Communications in Europe

successive programmes, and is currently taking place under the ECOSYS research project.

The first methodology and accompanying analysis tool was SYNTHESYS, a simple geometric model for quantifying duct and cable lengths. The second methodology, TITAN, could be used to predict the cost evolution of network components based on a combination of learning curves and logistic functions. Later versions, OPTIMUM, TERA, and TONIC, have further enhanced the methodology to be able to cope with complex multimedia service and network structures. The most recent version, ECOSYS, brings improvements especially in the assessment of operational expenditures. (Olsen 1999, Lähteenoja et al. 2006)

The methodology and approach has been used in practice by several telecommunication operators in Europe, including e.g. Deutsche Telekom, France Telecom, Telenor, and KPN. (Lähteenoja et al. 2006)

2.2 Elements of business case study

Defining a business case for examination with the ECOSYS tool requires modelling the incoming and outgoing cash flows on a yearly basis. Identifying and quantifying these cash flows, namely revenues and costs, is a key challenge in modelling a business case accurately, since the calculation and final numeric results will be based on them.

2.2.1 Study procedure

The basic procedure for conducting a business case study using the ECOSYS methodology is the following:

1. Make a survey of necessary applications and future needs.
2. Translate the future needs into relevant services and/or architectures.
3. Evaluate the services and/or architectures with the tool.
4. Interpret the tool’s economic output and draw conclusions.

(Bouillon et al. 2002)

The analysis procedure then requires input data of the technology being examined as well as the implementation environment. A given technology can have for example certain quantifiable service capabilities as well as monetary costs associated with set-up, operations, and maintenance. The implementation environment can cover for instance the geographic, demographic, competitive, and regulative aspects, which in turn can affect the scope and costs of the implementation.

2.2.2 Concepts and frameworks

To construct a business case, we can utilise the concepts and frameworks of business models, value chains, value networks, and business ecosystems for analysing the complex interactions between different players.

Business models

We can find various definitions for the term business model in the literature. For the purposes of this thesis, we apply the work of Lähteenoja et al. (2006) and define business model as follows: the set of roles in a value network a certain business player chooses to perform, the relationships it has with other players, and its cost structure and sources of revenue.

Value chains and value networks

Porter's (1985) value chain framework describes how an industrial organisation buys raw materials and transforms them into physical products. The process consists of distinct value-adding activities with cost and value drivers. The purpose of the framework is to identify ways to maximise value creation and minimise costs.

In a converging industry setting, such as mobile TV, traditional company-specific value chains may no longer adequately reflect the complex reality. Alongside Porter's value chain framework, which focuses on cost minimisation and competition, we can use the value network approach, which better acknowledges the existence of collaboration between different players.

We apply the view of value networks as proposed by Smura (2006). He cites Li & Whalley (2002) writing that "A value network can be seen as a series of intertwined value chains where some nodes are simultaneously involved in more than one value chain". As a requirement for a successful value network, Smura also highlights the importance of providing a whole product, defined by Moore G. A. (1991) as the "Minimum set of products and services needed to fulfil the compelling reason to buy for the target customer". In the case of mobile services, this means that several parallel value chains in the mobile value network must be in place to deliver value to the customers, as shown in Figure 1 below.

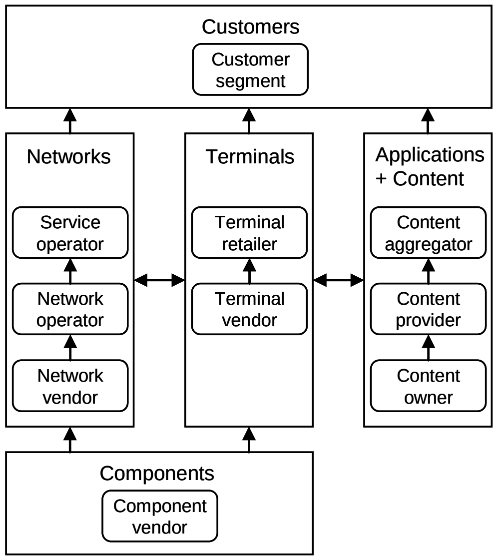

Figure 1: Simplified mobile value network (Smura 2006).

Business ecosystems

Moore J. F. (1993, 1996) writes that a company should be viewed not as a mere member of a single industry, but as a part of a business ecosystem, an economic community of interacting organisations evolving around an innovation and crossing a variety of industries to produce goods and services to end customers. The community can consist of suppliers, lead producers, competitors, and other stakeholders working co-operatively and competitively. The members of the community co-evolve their capabilities and roles over time, and tend to align themselves and their investments with the directions and shared visions set by one or more 'leadership' companies.

According to Moore J. F. (1993), the birth of a business ecosystem consists of three essential stages that entrepreneurs or companies have to go through successfully:

1. Betting on a seed innovation that can lead to revolutionary products.
2. Discovering the right customer value proposition.
3. Designing a business that can serve the potential market.

After its birth, a business ecosystem faces competition from both inside and outside the community. It has to cope with challenges arising from expansion, leadership struggles, and self-renewal to fight other ecosystems.

In our view, Moore's business ecosystem theory is a good starting point for analysing the new business environment emerging around mobile TV, which connects together companies from two different industries: broadcast media and mobile communications. Unlike static value chains and business models, business ecosystem theory acknowledges the evolution of different players and the roles they perform over time.

We apply the business ecosystem concept to analyse the central roles in mobile TV service delivery, and to see which role and business model arrangements could create most value for both mobile operators and broadcasters.

2.2.3 Scenario approach

In this thesis, we adopt a guideline framework proposed by Ravera et al. (1998) for techno-economic modelling of telecommunications networks. The framework uses input scenarios to analyse the environment.

Ravera et al. define a scenario as a "Description of a network environment… in which there is provided a set of services to a number of users within a certain area and timeframe. It includes both a starting situation and a target for the network and services evolution."

To limit the inherent complexity, Ravera et al. decompose a full scenario into four categorised (sub-) scenarios. The four categories are the following:

1. Regulation/competition,
2. technology,
3. environment, and
4. service.

A regulation/competition scenario describes how the market is regulated for instance in terms of possible decoupling of service and network operation, tariff structures, significant market power, and operator revenues. The scenario also describes the state of competition through for instance the market shares of different network and service operators.

A technology scenario describes the technologies, systems, and architectures needed to provide the services. It holds the current and future network architecture, and the associated operational and capital expenditures.

An environment scenario describes the current and future status of network infrastructure, and the geography and demographics of the market. It thus holds for instance the division of the geographic area into different classes by the population density.

A service scenario describes the services and applications provided by the service operators. It holds the different service types, the current and future penetration of the service types, and the subscription tariffs. For the purposes of this thesis, we include also the different business models and the associated operational expenditure in the service scenario.

2.3 ECOSYS tool

The ECOSYS tool is an integral part of the chosen techno-economic methodology approach for evaluating a business case. The MS Excel based tool has been developed for calculating the value, profitability, and other financial indices for telecommunications architecture related business cases. It enables a structured and consistent method of performing a cash flow analysis.

2.3.1 Tool and calculation overview

ECOSYS tool takes a bottom-up approach in evaluating the economic feasibility of a network or service implementation. This means that it sums up small pieces to generate aggregate cash flows. These pieces are for instance the service spending by consumers and network element specific costs.

User first enters the input data into a financial model based on which the tool then calculates the total revenues, investments, cash flows, and profits for each year for the chosen study period. The output of the model includes key financial indices meant for decision-making.

Figure 2 below gives an overview of the ECOSYS methodology and the elements in the tool. Game theory and real options are alternative strategic and financial methods, which can be included in the tool, but we do not employ them in this thesis.

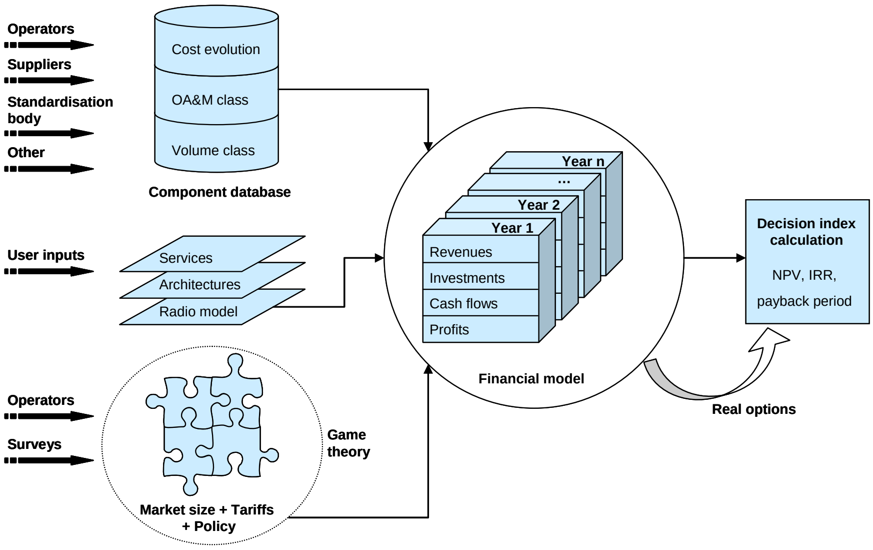

Figure 2: Calculation elements in the ECOSYS tool (Lähteenoja et al. 2006).

2.3.2 Calculation steps and inputs

The following steps need to be taken for completing a techno-economic evaluation in the ECOSYS tool: setting a study period, defining a set of services, defining network architecture, defining OA&M costs, defining economic and other parameters, and running simulations on the model.

Setting a study period

User defines the study period in years so that it best suites to the business case. What is a reasonable period depends on the economic life of the required investments, which in turn depend on the type and size of network being deployed.

Defining a set of services

User defines the set of services included in the project. A service is an abstract element that has a specific connection and usage tariff, a potential market size and a market penetration over the study period. These can be projected using built-in formulas or input by hand. ECOSYS combines the annual potential market size, annual market penetration, and annual tariff information to calculate the revenues for the services.

Defining a network architecture

User defines the network architecture setting for the network. For cable networks, ECOSYS uses a geometric model for calculating cable and duct lengths. In case of radio networks, such as DVB-H, no geometric model is needed. Resulting from the architecture setting is the 'shopping list', i.e., the installed base of equipment over time. From the installation schedule and cost prices for each component, ECOSYS calculates the annual capital expenditure (CAPEX) and associated depreciation over the study period.

Defining OPEX

OPEX stands for operational expenditure, i.e., the on-going costs for running a business. It includes all costs associated with the business case except the capital expenditure. Kaleelazhicathu et al. (2005) have identified the following OPEX categories commonly present in telecom operator business:

- Maintenance of equipment and components
- Equipment and software licences, maintenance outsourcing
- Sales and marketing, customer acquisition
- Customer provisioning
- Customer care
- Charging and billing
- Service management
- Network management
- Product/platform development
- Rental of physical network resources
- Roaming
- Interconnection
- Yearly cost of radio spectrum licences
- Regulation
- Content

Defining economic and other parameters

Project specific economic inputs such as discount rate, period of tax deductibility of losses, and tax rate must be input. These inputs affect the way the annual cash flows are handled. The discount rate depends on the risk level of the project and the average cost of capital of the company, and the tax policy varies by country.

OPEX and CAPEX are generally treated equally in a cash flow analysis. The distinction of OPEX and CAPEX elements becomes important only when we consider corporate taxes on profits. A business can deduct all of its annual OPEX items from revenues, but of CAPEX items, it can deduct only the annual depreciation. The corporate taxes matter only when the operator has any profits to pay taxes on.

Other parameters can be for example the network construction speed or percentage of people preferring a bundled handset. User can define virtually unlimited amount of custom parameters to be included in the calculation.

2.3.3 Economic outputs

ECOSYS tool combines the annual service revenues, investments (CAPEX), operational expenditure (OPEX), and economic parameters to calculate several financial indices and other results for the study period. The calculated financial indices are:

- Net present value (NPV),
- internal rate of return (IRR),
- rest value,
- payback period,
- NPV before taxes, and
- IRR before taxes.

Other results calculated for each year in the study period are:

- Investments,
- cost prices (price curves),
- running costs,
- maintenance,
- revenues,
- cash flows,
- depreciation,
- profits,
- taxable income,
- taxes,
- retained cash flow,
- cash balance,
- earnings before interest, taxes, depreciation and amortisation (EBITDA),
- earnings before interest and taxes (EBIT),
- interest, and
- earnings before taxes.

2.4 Interpretation of results and sensitivity analysis

The basic output of a techno-economic analysis is the economic profitability of the examined business case. The profitability calculations are most often based on cash flow analysis, which either sums up annual net cash flows as such or as discounted to the beginning of the study period taking into account the project's risk and time value of money.

Cash flow analysis of a project is based on an incremental approach, in which only the costs and revenues directly related to the evaluated project are considered, i.e., the cash flows that will materialise only if the project is undertaken and vice versa. For instance, a company's general overhead costs should not be calculated if they are not directly caused by the project, although in accounting it would be justified to distribute them evenly to all projects. (Brealey et al. 2006, pp. 114-116)

The most typical cash flow based calculation methods are net present value (NPV), internal rate of return (IRR), and payback time. Each of these methods has its own set of strengths and weaknesses, but NPV is generally considered the most consistent and elegant of them. (Brealey et al. 2006, pp. 85-99)

In this thesis, we use NPV to rank different operating models against each other. NPV uses a discounted cash flow (DCF) approach. The interpretation of an NPV result goes so that if the outcome is negative, a company would destroy value by investing in the project, and if the outcome is positive, the company would create value by investing in the project. In other words, a company should only undertake a project that has a positive NPV.

The drawback of using this kind of plain DCF approach is that it assumes that the project is held passively, neglecting the effect of management. In real world, undertaking a project with negative NPV can be justified, if it is e.g. a strategic project enabling further projects. Similarly, deciding not to undertake projects with a positive NPV is also justified, if waiting enables even higher returns. Management also has the option to abandon or expand the project early on if it turns out worse or better than expected. Such effects are invisible in regular DCF valuation (which we use in this thesis), but could be captured by using real option valuation (ROV) approach. (Brealey et al. 2006, pp. 597-610)

A cash flow analysis is often built upon numerous assumptions and uncertain variables. The underlying uncertainty can be interpreted as the risk in the project.

Sources of risk can be e.g. market demand, competition, regulation, technology, operations, investments, and so forth. A single NPV value can then indicate only one possible result from the set of all different outcomes. Therefore, it is valuable to conduct a sensitivity analysis to get a view of the variability of the outcome and the overall risk of the project.

Sensitivity analysis means studying how the variation in the output of the model can be apportioned to different sources of variation. It can be used to identify which variables contribute the most in the output's variability.

A traditional sensitivity analysis examines the effect of changing one input parameter at a time to identify the most significant variables. However, this is not sufficient if a more complete picture of the overall uncertainty is needed. (Elnegaard and Stordahl 2004)

In this thesis, we utilise a multivariable sensitivity analysis, based on a Monte Carlo simulation. To do this, we use the Crystal Ball™ software with Monte Carlo simulation and statistical analysis capabilities on top of the ECOSYS model to perform automatically a large number of simulation runs and collect statistical data. Monte Carlo simulation is a widely used stochastic computational algorithm for simulating the behaviour of various complex physical or mathematical systems.

Compared to a stand-alone spreadsheet calculation model providing only a single result at a time based on e.g. the expected values of parameters, a model using Monte Carlo simulation can randomly generate thousands of values for each uncertain variable. The simulation engine pseudo-randomly selects a value from a defined range and shape of distribution for every variable and then recalculates the spreadsheet. By doing this repeatedly and by storing the results for later analysis, the engine simulates the model's behaviour with numerous different combinations of parameter values.

The main benefit is that a sensitivity analysis done with Monte Carlo simulation can tell us what is probable, whereas traditional sensitivity analysis can only tell us what is possible (Elnegaard and Stordahl 2004). Monte Carlo simulation then helps us to analyse the effects of simultaneous changes in different parameter values and to estimate the expected and extreme values of the business case.

However, even after a sensitivity analysis, the obtained numerical results must not be seen as universal outcomes for the real value of the business case. Instead, they represent the possible values of the business case in simulated market conditions with a number of underlying assumptions. Moreover, if the calculation model and parameter ranges do not reflect reality, the simulation outputs will not do it either.

2.5 Shortcomings of methodology

Majority of uncertainty is potentially built in a techno-economic analysis when different cash flows are projected over long periods using a number of assumptions and variables, since predictions about the future are by definition uncertain.

In many cases, these assumptions and variables concerning uncertain future events must be estimated based on e.g. expert opinions or best guesses, rather than on solid scientific facts. It is then clear that the analysis output is at best only as good as the input data, even when the calculation logic itself would accurately imitate reality. The same however applies to any method of forecasting future cash flows. ECOSYS mitigates this problem by making the assumptions explicit.

This uncertainty can be limited to a certain degree by using several sources of information for each parameter whenever possible. This, accompanied by making each assumption explicit, helps to improve the transparency of the calculations, which in turn helps to improve the results' usefulness in practice.

Moreover, the simulations rely on approximations and simplifications, but the model can output results at the accuracy of single euros. This can create an illusion of accuracy, although the starting values can be in the scale of thousands or millions of euros. To overcome this illusion in this thesis, we report all results with accuracy in proportion to the starting values.

Finally, the methodology is not optimal for studying the effects of changes in socio-economic factors or changes in consumer needs and desires. The overall cultural context in which the techno-economic mechanisms are situated can also have a great effect on technological change, as discussed by Stein (1995). Capability to model such factors consistently could prove useful in studying the adoption of content service innovations such as mobile TV. However, this is not an actual shortcoming of the methodology, since ECOSYS has not been designed for such analysis. In this thesis, we try to incorporate such effects in market demand forecasts.

2.6 Chapter summary

In this chapter, we have covered the techno-economic analysis as research methodology through listing the different elements in the analysis from inputs and outputs to the interpretation of results. We have also highlighted the shortcomings of the methodology.

We have discussed various concepts and frameworks for studying business cases: business models, value chains, value networks, and business ecosystems. We have also introduced a scenario-based approach to organising and modelling the regulative, technical, service-related, and environmental considerations of the business case.

Most importantly, we have presented the ECOSYS tool and its operation. We have gone through the concrete steps required to build a model of a network business case and listed the financial outputs of the tool. We have also introduced the Monte Carlo simulation approach we use for sensitivity analysis.

3 Techno-economics of IPDC/DVB-H services

In this chapter, we describe the elements and assumptions we use to construct the techno-economic ECOSYS model for the IPDC/DVB-H mobile TV service in Finland. We first define the study period, and then proceed to cover the business case circumstances thoroughly using the scenario framework of regulation/competition, technology, service, and environment scenarios.

We build the techno-economic calculation model from a service operator perspective. The focus is therefore on the potential market size, market demand, and service revenues rather than technical implementation or network architecture. Consequently, we use the ECOSYS tool for a rather different kind of business case than the ones the tool has primarily been designed for. The modelling challenge thus also tests the applicability of the methodology for evaluating new mobile services and related ecosystems.

3.1 Study period and economic parameters

The business case of broadcast mobile TV has many moving parts. Therefore, we want to have a study period that is reasonable for making penetration forecasts, but also one that enables making practical conclusions about the profitability of the business case. We then choose to have a study period of roughly five years, from April 2007 to end of 2011.

We believe that five years is a long enough time for a mobile service to catch momentum if it ever will. However, this does not mean that the service should reach its peak usage during the first five years. At the outset, we can expect that in five years time mobile TV can be an every-day mobile service for many consumers, a slowly advancing niche application, or a nearly forgotten failed venture. We can also expect that during five years, new technology hypes will be introduced and potentially be attracting the limited focus and resources of the mobile industry.

Then again, even five years is a rather long time for making meaningful forecasts about mobile services, especially with starting data as scarce as with mobile TV in Finland.

Corporate tax for profits in Finland is 26%. We set the cash flow discount rate for the business case to 8% for all operator types and business models. The discount rate is roughly based on after-tax weighted average cost of capital (WACC) rates we estimated for two major telecommunications operators in Finland. It is reasonable to argue that using the same discount rate for all business models and operator types is not optimal, since the level of risk can vary between them. However, estimating the risk level separately for each business model and converting it to discount rate would not be without problems either. Therefore, we choose to use a constant rate and consider the varying risk level when interpreting the results.

3.2 Mobile TV business ecosystem in Finland

To model the business ecosystem emerging around DVB-H mobile TV, we can begin by looking at the value chains of mass media and mobile content business. We cover these two briefly before presenting the business ecosystem we use in this study.

3.2.1 Value chain of traditional mass media

Nieminen and Pantti (2004) have discussed the traditional value chain of mass media. According to them, the most common roles in the value chain are as follows:

Content production → Aggregation → End-product packaging → Distribution → Reception

In brief, the production phase includes the original creation of the content. Aggregation is the sourcing of content from various producers. End-product packaging is the offering of the content to the distributors or end users. Distribution is the delivery of the content to the end users. Reception is the consumption of the content.

Nieminen and Pantti (2004) write that the role of aggregators is central in the media business, because the aggregator often becomes the holder of the usage rights for the original production, and can therefore trade the rights further.

For example, the TV channels in Finland may compete of the regional rights to show the best foreign TV series. In this case, the Finnish TV channel acts as an end-product packager and distributor. For some programming content, the Finnish TV channel can be also the content producer and/or the content aggregator.

Often the mass media field consists of a multitude of specialised players and a few large, vertically integrated players involved in everything before the reception. Different distribution technologies and digitalisation have further complicated the picture, and horizontal integration across different media is common, leading to cross-media content provisioning under the same brand.

Mass media production has five distinct sources of financing:

1. consumers,
2. advertisers,
3. third parties,
4. publishers, and
5. public sector.

Examples of consumers paying for the TV channels in Finland are on one hand the TV licence fees collected for the national broadcaster YLE, and on the other hand the subscription movie channels. The commercial channels financed by advertising do not collect direct consumer payments, but the consumer still pays their operations indirectly by buying products advertised on the channels. (Nieminen and Pantti 2004).

TV viewing models

The viewing models of television can be classified according to how they collect the money from consumers. The most important viewing model in Finland is currently the free-TV financed by licence fees or advertising. If the consumer has to pay directly for viewing, the model is called pay-TV. Pay-TV can be based on a paid temporal subscription like a channel package, or pay-per-view like a single ice hockey game. Video-on-Demand can also be thought as a form of pay-TV, although it resembles video renting rather than television.

The success of free-TV financed by advertising is dependent on the channels' ability to offer the advertisers desired audiences and target segments. Therefore, the channels are inclined to show programming responding to the taste and interest of the solvent audiences.

In research, mass media is therefore said to operate in a dual product market. The consumer market consist of people acquiring products of the media industry by buying, subscribing, or by paying TV licence fees. The other market consists of the audiences of mass media, i.e., the advertising market in which the actual product being sold to advertisers is the audience. (Nieminen and Pantti 2004)

3.2.2 Value chain of mobile content

The value chain of mobile content, presented in Figure 3 below, has some elements in common with the value chain of mass media.

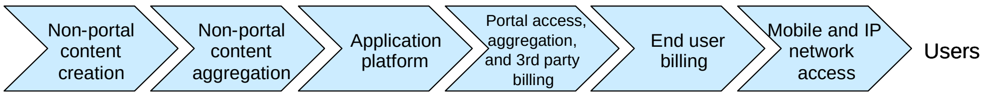

Figure 3: 3G value chain (UMTS Forum 2001).

In brief, the first block arrow, 'non-portal content creation' means the original source of the content. The 'non-portal content aggregation' means gathering and storing of content from various producers together. Application platform part provides tools for the content creators to build their content and applications on. Portal access and aggregation means providing a website or catalogue like access to the services and content. Third party billing means the inclusion of the third party content in the service operator's end-user billing. The mobile and IP network access means providing the network connectivity to the end-user.

Strong vertical integration is also present in the mobile content value chain, although regulation can force the decoupling of service and network operation in some markets, which has led to the appearance of mobile virtual network operators (MVNO).

3.2.3 Generic business ecosystem of mobile TV

In mobile TV, mobile phone is the point of convergence for broadcast mass media and mobile communications. However, the biggest challenges do not lie in the technical solutions but in the relationships between different companies participating in delivering the services. (Kivisaari and Luukkainen 2005)

For broadcast mass media, mobile TV promises new possibilities enabled by the existence of a widely adopted return path, the potentially abundant number of personal devices (i.e. reachable audience), and a secure billing mechanism. Mobile industry on the other hand can be interested in extending their service range with TV content, and/or in making money by controlling the customer interface and interactions. Kivisaari and Luukkainen (2005) discuss the new business opportunities for different parties.

Note that although the IPDC/DVB-H service delivery does not necessarily need the mobile networks (it uses a separate broadcast network much like conventional terrestrial TV), the most apparent way to provide a return path for a mobile phone type of device is via the mobile networks.

Mobile TV then connects the broadcast mass media and mobile content value chains together creating a converging industry setting. In such context, modelling the business case using traditional value chain approach would be difficult. Therefore, we choose to apply business ecosystem approach.

Moore J. F. (1993) suggests that to emerge, a business ecosystem has to design a compelling customer value proposition, i.e., the total service offering, so that the consumers would be willing and able to buy it. In addition, the ecosystem must be able to serve the potential market in the long term, i.e., it must be able to create a functional value network to deliver the service profitably.

To construct a base of such a business ecosystem emerging around IPDC/DVB-H service in Finland we partly apply the business models suggested by Kivisaari (2006), the Digital Terrestrial Television Action Group, DigiTAG (2005) and the European Broadcasting Union, EBU (Weck and Wilson 2006). We also let the interviewed experts state their views on the roles and interactions, and look at the comparative arrangements in several mobile TV pilots and live networks around the world, studied by Braet et al. (2006).

Figure 4 below shows the resulting generic business ecosystem we use in this thesis as a starting point for forming various business models. We call it generic, since it does not devise actual business players or business models. Instead, the generic ecosystem consists of a set of significant roles and possible interactions between them. One player can choose to perform one or more roles based on its business model, and several players can perform a given role simultaneously. The four different types of arrows in the figure signify the possible interactions between the roles. We are interested primarily in the monetary flows, shown as either solid or dotted red arrows.

The generic ecosystem might not be complete or exhaustive about the number of roles and interactions involved in the real world. Instead, it shows the roles and interactions we identified as having relevance for our study and serves in our view as a reasonable illustration of the playing field.

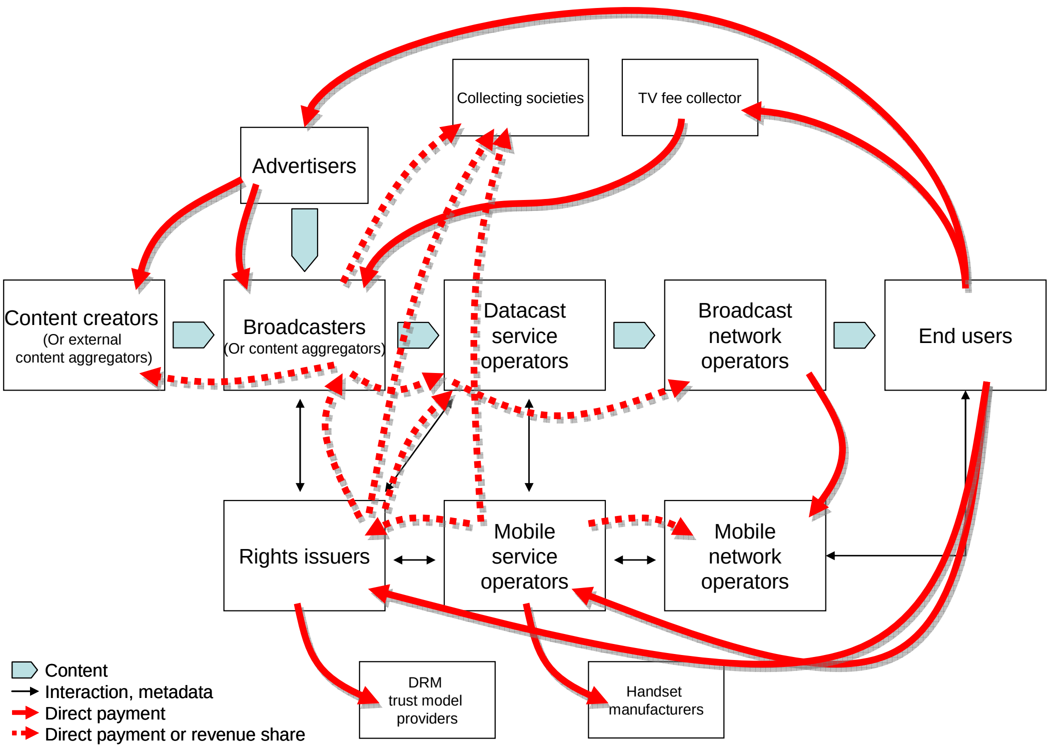

Figure 4: Generic business ecosystem of IPDC over DVB-H in Finland.

Table 1 below describes the roles in the generic ecosystem, applying the terminology used by DigiTAG (2005), EBU (2006), and Kivisaari (2006).

Table 1: Roles in business ecosystem (DigiTAG 2005, EBU 2006, Kivisaari 2006).

Role name	**Role description**
End user	Has an IPDC/DVB-H enabled handset, consumes mobile TV services, and pays for them directly or indirectly.
Broadcast network operator	Owns a DVB-H frequency licence. Operates the DVB-H network as well as the IP multicast network carrying broadcast streams to the transmitter sites.
Datacast (service) operator	Performs the central management of a technical mobile broadcast platform and sells the radio capacity.
Broadcaster	Runs one or more mobile TV or radio channels by creating the content in-house or by buying it from content aggregators/creators.
Content aggregator	Sources content from many content creators and acts as a broadcaster, or resells the airing rights.
Content creator	Produces the original content.
Rights issuer	Accepts purchase requests, sends related Digital Rights Management (DRM) rights objects to mobile terminals, and creates according billing data records.
Mobile service operator	Provisions mobile services to end users. Has a billing relationship with mobile subscribers.
Mobile network operator	Operates a mobile network and sells its capacity to mobile service operators and MVNOs.
DRM trust model provider	Certifies the robustness of the digital rights management (DRM) implementation.
Handset manufacturer	Manufactures IPDC/DVB-H enabled handsets and sells them to retailers such as mobile operators.
TV fee collector	Collects TV fees from end users possessing a television receiver.
Collecting society	Collects payments for the usage of copyrighted music for the copyright owners.
Advertiser	Pays for advertising minutes on TV or radio programming, and/or sponsors content creation.

3.3 Regulation/competition scenario

In this section, we describe what considerations we include in the regulation/competition scenario and how they limit or open possibilities for the business ecosystem.

Skouby and Tadayoni (2006) write that a regulatory trend of liberalisation has transformed the telecommunications business during the last 20 – 25 years, removing the political-ideological basis for the national monopolies and introduced the ideas of trade and market forces in telecom services. The national monopolies, which previously dominated the markets, have been substituted by systems separating operations, policymaking and regulation. An independent regulator as a neutral institution oversees the competition and tries to level the playing field between the government-owned incumbents and newcomers.

Finland was among the first countries to liberalise its telecommunications markets. The Finnish Ministry of Transport and Communications is responsible for the government of the communications sector. It looks after issues relating to communications networks, e-commerce, and the media, and monitors the working of the communications markets, the development of the information society, and the switchover to digital television. Finnish Communications Regulatory Authority (FICORA), an agency under the ministry, handles the according regulative and administrative tasks. (Ministry of Transport and Communications, 2007)

In effect, FICORA is responsible for the protection of the rights of the user of communications services, i.e. the consumer. It provides data on the development, pricing, and service level of communications markets and services. It also plans and administers the use of radio frequencies, and collects television fees and licence fees to help finance public service programme production. Monitoring the content and advertising of television and radio programmes belongs also under FICORA's tasks. (FICORA 2007a)

Communications, including broadcasting and mobile telecommunication, is regulated under the Communications Market Act of 2003 and its amendments. For the purposes of this thesis, we assume the current regulative setting to be in effect throughout the study period.

3.3.1 Broadcast network operation

With broadcast network operation, we mean the management of a DVB-H network of radio transmitters as well as an IP multicast network carrying broadcast streams to the transmitter sites.

The Communications Market Act (2003) states that a licence is required for providing a network service that uses radio frequencies in a digital terrestrial mass communications network (broadcasting).

In 2006, Finnish government awarded the first, and to date only, DVB-H spectrum licence and multiplex to Digita. Digita takes two roles in the mobile TV ecosystem: the datacast service operator and the broadcast network operator. It thus also sells the capacity and manages the technical platform of mobile broadcasts.

According to the DVB-H licence conditions (Ministry of Transport and Communications 2006a), Digita has agreed to build the network to cover 40% of population by the end of 2007. Network coverage expansion beyond the 40% is left to Digita's own decision and negotiations with the service parties.

The DVB-H spectrum licence conditions also state that Digita cannot act as a service operator, and must therefore sell the network capacity to external parties. Furthermore, Digita's DVB-H capacity pricing must be non-discriminatory and cost oriented. This means that the pricing must be transparent, same for all buyers, and based on true costs plus a fair and reasonable profit margin.

Although Digita has not been declared a significant market power (SMP) company in DVB-H, the above conditions are in effect comparative to an SMP ruling. According to our knowledge, the fair and reasonable margin has not been defined exactly and depends on the market risk.

The licence conditions also restrict the maximum amount of capacity sold to one player to 1/3 of the total to enable a healthy market – one party then cannot buy the whole capacity and resell it at a higher price.

According to interviewed experts, in the case that several service operators would provide the same channel and buy the required capacity for it, Digita would split up the capacity bill evenly.

We assume that Digita will remain the sole holder of DVB-H spectrum licences, i.e., if further licences are granted, they go to Digita, as has happened with DVB-T.

According to interviewed experts, mobile TV does not have any universal service or must carry obligations regarding the national free-TV channels. Digita is therefore not required to deliver any given channels or build the network to full population coverage.

Since the radio capacity is scarce, we expect Digita to air each channel only once and the service operators to choose which channels they want to include in their offering. One consequence of this is that the service differentiation possibilities for service operators can be more limited than in a model where each service operator would also operate own network and arrange the channels independently.

Digita's pricing for a nationwide DVB-H television channel is as shown in Table 2 below. We got the pricing information from Digita upon request. The base price for a national TV channel is EUR 39,400 per month, based on 40% population coverage. Digita gives ramp-up discounts during the 2007. If Digita expands the network's population coverage beyond 40%, it can adjust the price upward to match the increased costs. Digita has yet to publicise the pricing for regional capacity, but we can expect them to be somewhat lower.

Table 2: DVB-H capacity pricing for a nationwide TV channel (Digita).

Period	**Network's population coverage**	**EUR per month (Excluding VAT 22%)**
First three months of 2007	25%	5,900
Last nine months of 2007	25% - 40%	19,700
Beginning of 2008	40%	39,400

Table 3 below shows a rough comparison between DVB-T and DVB-H capacity pricing. The DVB-T pricing information is from Digita (2007). Note that these numbers assume no DVB-H network expansion beyond the 40% population coverage, and that the whole population under DVB-T network coverage has access to digital terrestrial TV. The comparison shows that between 500,000 and one million DVB-H handsets are needed to get similar capacity prices; EUR 0.047 per person for a nationwide DVB-T channel vs. EUR 0.079…0.039 for a DVB-H channel. All prices exclude VAT 22%.

Table 3: Comparison between DVB-T and DVB-H channel capacity pricing.

DVB-T, technical network coverage	Population coverage	Population coverage, %	EUR / month / TV channel (4Mbit/s)	EUR / month / person
Nationwide digital TV	5,200,000	100 %	245,000	0.047
DVB-H, technical network coverage	**Population coverage**	**Population coverage, %**	**EUR / month / TV channel**	**EUR / month / person**
Mobile TV first 4 months	1,300,000	25 %	5,900	0.005
Mobile TV next 9 months	1,700,000	32 %	19,700	0.012
Mobile TV Jan. 2008	2,100,000	40 %	39,400	0.019
DVB-H, handset coverage	**Handset adopters**	**Handset adopters / population, %**	**EUR / month / TV channel**	**EUR / month / person**
Mobile TV	10,000	0 %	19,700	1.970
Mobile TV	100,000	2 %	39,400	0.394
Mobile TV	500,000	10 %	39,400	0.079
Mobile TV	1,000,000	19 %	39,400	0.039
Mobile TV	1,500,000	29 %	39,400	0.026
Mobile TV	2,000,000	38 %	39,400	0.020

3.3.2 Broadcast service operation

With broadcast service operation, we mean the pricing, sales, and marketing of mobile TV services to end users, and managing the distribution of DRM rights objects. A broadcast service operator then performs at least the rights issuer role.

In principle, any player except Digita can become a broadcast service operator. In this thesis, we assume that both broadcasters and mobile service operators can become broadcast service operators. Moreover, we assume that a broadcaster becoming a broadcast service operator can bill the users directly or through a mobile service operator in the mobile phone bill.

3.3.3 Mobile network and service operation

Mobile network operator is an operator that provides a public mobile network in its ownership or for other reasons in its possession for the purposes of transmitting, distributing, or providing messages. Operating a public mobile telecommunications network requires a licence. (Communications Market Act 2003)

Mobile service operator is an operator that transmits messages over a mobile network in its possession, or obtained for use from a mobile network operator. (Communications Market Act 2003)

There are three licensed nationwide mobile network operators in Finland: Sonera Mobile Networks Oy, Elisa Oyj, and Finnet Verkot Oy. All three have licences for both GSM and WCDMA network operation.

A mobile operator with both mobile service and mobile network operations is a vertically integrated mobile operator. Communications Market Act (2003) holds that such operators must separate their service and network operations in accounting. As the three nationwide mobile network operators in Finland are vertically integrated telecommunication groups, we can use the term mobile network operator (MNO) to refer to a vertically integrated mobile operator.

Currently none of the large three MNOs has been ruled as a significant market power (SMP) regarding mobile network access and upstream traffic wholesale. None of them is therefore obliged to lease mobile network or enable upstream traffic for external service operators. Commercial factors have however led to voluntary leasing of networks and upstream capability, enabling the existence of external service providers (SP) and mobile virtual network operators (MVNO). (FICORA 2004)

Communications Market Act (2003) does not currently define or distinguish virtual network operators, and they are therefore regulated as actual network operators. In this thesis, we resort to Ministry of Transport and Communications (2005a), and define a mobile virtual network operator (MVNO) as a vertically integrated mobile operator, that:

- leases radio access network from a licensed mobile network operator (MNO),
- has its own core network with a mobile switching centre (MSC) and a home-location register (HLR),
- distributes its own subscriber identity modules (SIM) to its subscribers, and
- can make interconnection agreements with other network operators.

In other words, a MVNO acts both as a mobile service operator and as a network operator, but does not own a radio access network.

3.3.4 Handset bundling

Bundling the sales of a mobile terminal and a mobile subscription has been forbidden in Finland. A recent, temporary amendment in the Communications Market Act of 2003, however, allows bundling a WCDMA-enabled terminal with a mobile subscription. The amendment is valid from 1 April 2006 to 1 April 2009.

The maximum length of such a bundle period is 24 months, during which the WCDMA terminal may be locked to allow only a given operator's SIM. In practice, the bundling has meant that the customer pays the handset in 24 monthly instalments in his/her mobile subscription bill.

In this thesis, we assume that the permission to bundle a WCDMA terminal and a subscription will be continued beyond 1 April 2009, and be in effect during the whole study period.

In practice, this means that a DVB-H-enabled mobile phone can be sold bundled with a mobile subscription only if it is also WCDMA-enabled.

3.3.5 Content provisioning and broadcasting policy

Broadcasters or other content providers that want to broadcast content over DVB-H have to obtain a mobile TV programming licence from FICORA. These licences are currently available to anyone; the licensing process is lightened so that in practice filing in an application and paying a fee of EUR 100 per channel is sufficient. No new licence is required for simultaneous airing of channels already in digital terrestrial television, i.e., the digital terrestrial television licence is sufficient also for simulcasts in DVB-H. (FICORA 2007b)

Transmitting content other than TV or radio programming, for instance games or interactive services, in addition to a TV or radio broadcast, does not require a programming licence. (FICORA 2007b).

Distribution rights for the programming content must be licensed or bought from content owners. These are in general handled through agreements between the broadcaster and the content owner. In addition, a broadcaster has to pay licence fees for copyrighted music used in the programming through collective licensing.

Collective licensing is done by a licensing organisation (collector society) on behalf of its members (authors, composers, performers, etc.), or on behalf of also other right-holders of that particular area of rights (extended collective licensing). (Copyright Act 1961 and its amendments, Huuskonen 2006)

According to interviewed experts, the free-TV channels with a national licence in conventional digital TV cannot charge consumers directly or indirectly for watching. Otherwise they could be regarded as pay-TV, which would affect their status as ‘must carry’ channels in cable TV, and possibly breach the terms of their programming licences. A cable TV operator can however charge for cable access. It is not clear if similar arrangement is possible for simulcasts of these free-TV channels in DVB-H viewing.

3.3.6 Spectrum policy

Spectrum in the UHF band for one IPDC/DVB-H mobile TV network (multiplex) has been allocated for the whole country, excluding Åland, until 2026 (Ministry of Transport and Communications 2006a).

In theory, more frequencies could be allocated in the future, as Finland secured spectrum for altogether nine nationwide networks (multiplexes) in the ITU Regional Radiocommunication Conference RRC’06 last summer. (FICORA 2006a)

The new frequencies can be used for digital television, radio, or multimedia. Seven of these are in the UHF band and two in the VHF band. In addition, new frequencies for several regional networks were obtained. In total, these frequencies provide capacity comparable to about 50 analogue TV channels. (FICORA 2006a)

3.4 Technology scenario

This section describes the technical considerations we address in building the calculation model.

3.4.1 IPDC/DVB-H network

European Telecommunications Standards Institute (ETSI) describes IPDC/DVB-H as "*An end-to-end broadcast system for delivery of any types of digital content and services using IP-based mechanisms optimised for devices with limitations on computational resources and battery. An inherent part of the IPDC system is that it comprises of a unidirectional DVB broadcast path that may be combined with a bi-directional mobile/cellular interactivity path. IPDC is thus a platform that can be used for enabling the convergence of services from broadcast/media and telecommunications domains (e.g. mobile/cellular).*" (ETSI 2006)

Figure 5 below shows the high-level implementation principle of an IPDC/DVB-H network, applied from Silvennoinen (2006). The broadcast network consists of multiple single frequency networks (SFN) carrying the DVB-H multiplex. An SFN consists of an Internet Protocol Encapsulator (IPE) and one or several transmitters and repeaters. Each IPE may have a different set of services, and the IPEs can be centrally managed by the service platform. Regional content can also be streamed locally into an IPE.

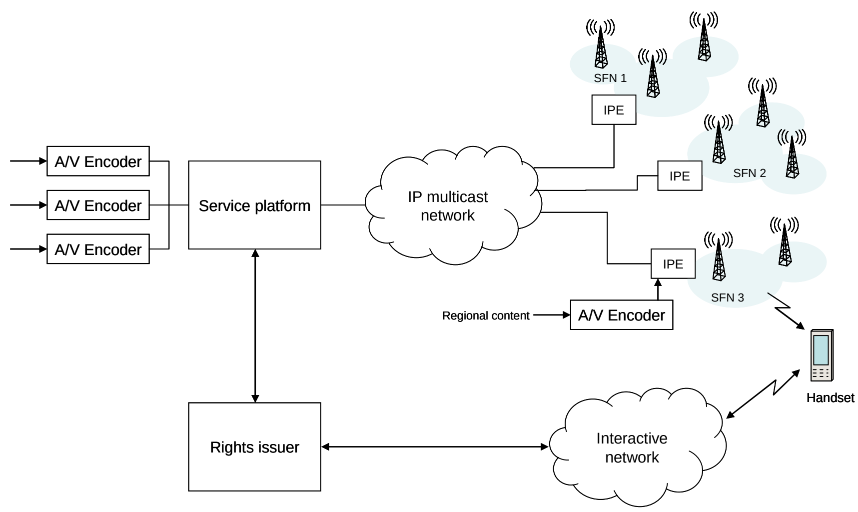

Figure 5: IPDC/DVB-H network implementation principle (applied Silvennoinen 2006).

DVB-H is a variation of the regular terrestrial digital TV standard DVB-T. The standard was designed so that in theory DVB-H could share a multiplex with DVB-T, which could be a way to deal with UHF frequency shortages in many European countries.

However, in practice the DVB-T is intended for fixed rooftop antennas and line of sight reception conditions, which enable large coverage areas for high-power broadcast towers. DVB-H reception conditions on the other hand are characterised by non-line of sight, multi-path impairments, Doppler impairments, strong propagation losses, and poor receiver antenna gain. (Bria and Gómez-Barquero 2005)

Consequently the existing DVB-T broadcast network infrastructure alone (i.e. broadcast towers) would not be dense enough to provide plausible DVB-H indoor coverage. A significant number of new broadcast towers or going to a hybrid solution using both existing broadcast towers and cellular base station sites (BTS) equipped with DVB-H transmitters or repeaters is therefore required.

The hybrid solution, also called cellular infrastructure re-use, lowers the required transmission powers for broadcasting sites. This is because directional transmitters and repeaters can be positioned in problem areas, so that the broadcast towers do not have transmit at very high power levels.

Consequently, as transmitter powers are lower, the SFN size, as well as the range of interference, is reduced. This increases the potential to use the same SFN frequencies again in nearby areas.

However, while saving frequencies and investment costs by using less powerful DVB-H transmitters at broadcast towers and cellular sites, the cellular site re-use implies investment and leasing costs proportional to the number of leased sites and transmission links.

According to interviewed experts, Digita will not build any new broadcast towers for DVB-H, and so they must opt for the hybrid solution, leasing BTS sites and transmission links from mobile network operators.

Silvennoinen (2006) writes that based on their simulations, the optimal network configuration consists of few large transmitter sites and several medium and small sized transmitter sites. Overall, the minimum power for the large broadcast towers should be 10 kW and for medium sized sites 4 kW – but local conditions may vary. In addition, the choice of modulation and the amount of forward error correction (MPE-FEC) have a considerable effect on the outcome.

Silvennoinen (2006) reports getting best results using high power omni-directional antennas in large sites whenever possible, and directional antennas in the medium and small sized sites. High antenna places are required to best utilise the high power omni-directional transmitters. This kind of configuration combined with a longer guard interval and signal delaying also proved effective in reducing interference.

We then assume Digita to use its own broadcast towers for the high power transmitters whenever possible, and lease BTS sites for less powerful directional transmitters and repeaters.

Transmission site and link leases

To be able to calculate the leasing revenues we need to estimate average lease fees for sites and links. Differing prices are used in various studies. We list a few of them here.

Smura et al. (2006) assume that BTS site rental including electricity would cost EUR 15,000 per year and that a 2 Mbps transmission link would be EUR 5,400 + EUR 240 per km.

According to Johansson et al. (2004) the rental for a macro BS site would be EUR 10,000 per year and EUR 5,000 per year for a micro site. An average transmission link cost would be EUR 5,000 per year for a BS.

According to data from Nokia, a DVB-H rental site could cost EUR 20,000 to set up, and then EUR 1,000 to operate per year. A 2 Mbps link could cost EUR 5,000 per year and a 34 Mbps link EUR 30,000 per year.

Note that the site rental can also depend also on the actual position of the transmitter device in the mast; higher masts are more expensive than lower and a top position is more expensive than lower positions (Silvennoinen 2006). For backhaul transmission links, the link length and capacity affect the price.

We then make a rough approximation that the average site lease is from EUR 3,000 to EUR 10,000 EUR per year, and transmission link lease would be from EUR 15,000 to EUR 20,000 per year per leased transmitter site. The leasing revenue calculation used in our model is given in the section covering the environmental scenario and network dimensioning.

3.4.2 Service platform

Figure 6 below shows the logical architecture of IPDC/DVB-H including the functional entities and interfaces as proposed by the DVB-H Project. The detailed descriptions for the entities and interfaces are given in ETSI TR 102 469 (ETSI 2006). For our model, the important aspect in the system is that the service management can use an interactivity path for access control. In other words, an IP-based network can be used for distributing access keys, i.e., rights objects, to end users.

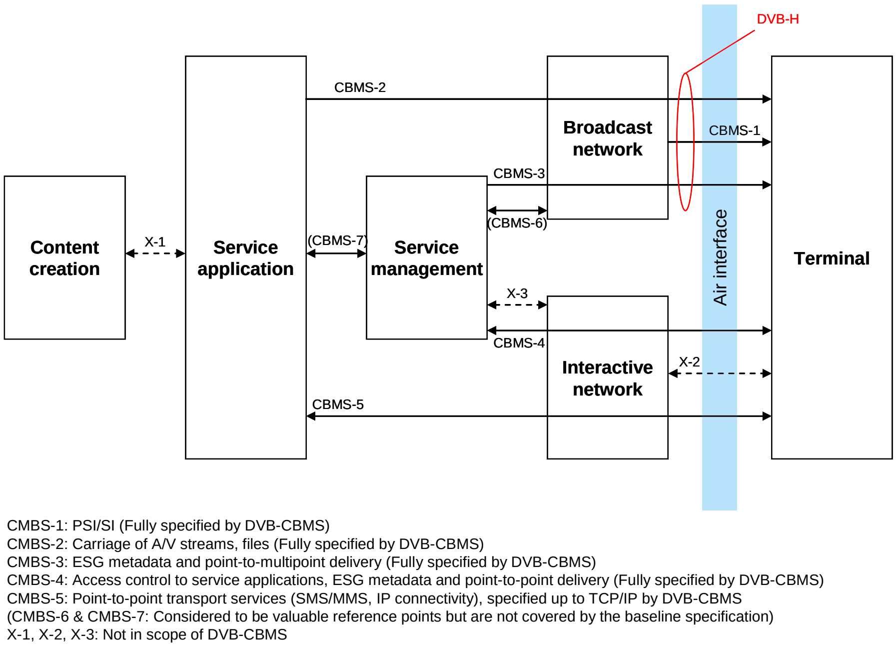

Figure 6: DVB-H architecture (redrawn, ETSI 2006).

For the purposes of this thesis, we can call the entity formed by the service application and service management the service platform.

Service platform handles producing the content IP streams (e.g. video streams) to the network. The IP streams are distributed over the multicast intranet to the IP encapsulators (IPE), which will package them into a ready DVB-H transport stream (TS) including time slicing and MPE-FEC. This TS is then distributed to the DVB-H transmitters. (Faria et al. 2006)

Figure 7 below illustrates the new network elements required by the IPDC/DVB-H service platform fitted on top of the mobile TV ecosystem, as implemented in Nokia Mobile Broadcast Solution (MBS) 3.0/3.1 (Nokia, 2006a). We apply this implementation because Digita chose Nokia as its service platform vendor (Nokia 2006b).

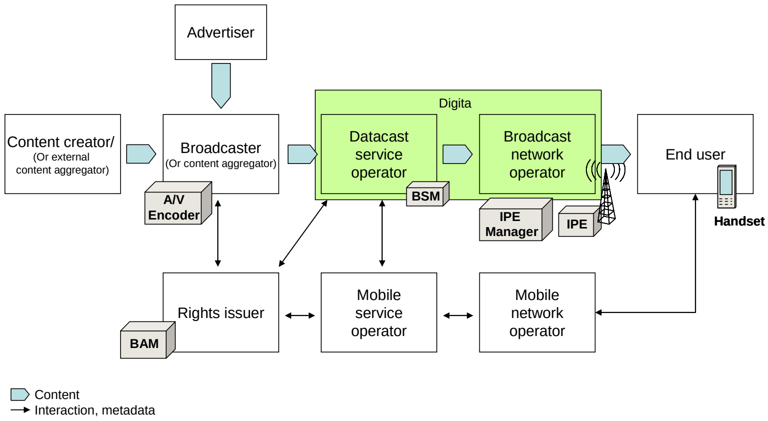

Figure 7: IPDC/DVB-H service system elements (Nokia, 2006).

The grey cubes represent physical network components needed in the IPDC/DVB-H service delivery platform. The new components are Audio/Video Encoder, Broadcast Service Manager (BSM), Internet Protocol Encapsulator (IPE), IPE Manager, and Broadcast Account Manager (BAM).

A service operator needs a BAM to perform the rights issuer role, i.e., for handling purchase requests, distributing access keys to subscribers, and generating according charging details and pre-paid reservations. The purchase requests and the DRM rights objects delivery are realised using a HTTP connection over the return path. (Kivisaari 2006)

We assume a service operator to acquire BAM machinery by application leasing, so that the price is based on the annual number of channel package subscribers.

We do not know the actual pricing, but we can assume it to range from EUR 1 to EUR 5 per subscriber per year.

3.4.3 Service capability

The DVB-H output bit rate can be calculated using the equation:

$$Bit\ rate = \log_2(M) \cdot K \cdot \frac{1}{T_S}$$

Where K is the number of OFDM carriers, T_S is the duration of transmission of one symbol, and M is the modulation constellation size. For instance, an 8 MHz channel using 4K mode (K=3408), 1/4 guard interval, and 16QAM (M=16) constellation has an output bit rate equal to around 20 Mbps. After Reed-Solomon error correction, the net bit rate is around 12 to 15 Mbps. (Herrero and Vuorimaa, 2004)

According to interviewed experts, the DVB-H network in Finland uses 16QAM modulation at least in the beginning, and the throughput is be around 10 to 12 Mbps. Using MPEG-4 video codec, a single TV channel requires a bit rate around 384 kbps. Electronic service guide and other control overhead however consume some of the capacity.

Signaali, the customer magazine of FICORA writes that the maximum number of concurrent TV services, i.e. TV channels, will be around 21 in the beginning. The capacity can be used for radio services as well, so that one TV service equals four to five radio services. (Signaali 2006)

In the model, we assume the total channel capacity to be around 21 TV channels until the end of 2008, and from 30 to 40 channels from 2009 on. Other services such as multimedia or application distribution are also possible.

3.5 Service scenario

In this section, we describe the business models and services included in the analysis. We present the different business models through the set of roles taken by a service operator, and the resulting interactions with other players in the ecosystem.

3.5.1 Viewing models

We assume there to be different viewing models in mobile TV. Some channels can be available free, financed by advertising or licence fees. Others can be available through pay-per-view or subscription. Some pay-TV channels or single programmes can be available separately, and some in channel bundles.

Some of the channels can be plain simulcasts of existing DVB-T channels, especially in the beginning. Almost all of the experts interviewed however expect that mobile TV specific content will be more important in the future.

The national broadcaster YLE has announced that its channels will be broadcast free of charge, if it decides to buy the capacity. YLE gets its financing from TV and licence fees collected by FICORA.

According to the interviewed experts, the case remains unsolved for the commercial free-TV channels financed by advertising. They have little incentive to buy expensive capacity in the beginning, when audiences are small. Experts consider that an audience of 100,000 to 500,000 would be adequate for advertisers to become interested. In DVB-T, the free-TV channels buy the capacity themselves, but they instantly get full or significant population coverage.

3.5.2 Offered services

While there can be different viewing models, there can be a variety of services. In the model, we divide the offered services into four categories: TV content services, interactive services, handset sales, and advertising sales.

The most important parameters we use for a service in the model are market penetration, annual tariff or spending, and service start year.

TV content services
TV content services consist of free-TV channels, pay-TV channels, channel bundles, and WCDMA video-on-demand streaming. Note that broadcasters can offer their regular DVB-T channels as free simulcasts outside the pay-TV channel packages. Table 4 below gives a complete listing and a short description of each service.

Table 4: TV content services included in the model.

Service name	Description
Channel packages, monthly subscription	- These are channel bundles consisting of two or more channels (TV & radio services). The packages can consist of new channels and/or simulcasts of existing DVB-T channels. - A service operator can (re)sell from one to three channel packages. - A channel package is available on a monthly subscription (flat rate). - Service is distributed through the IPDC/DVB-H network.
DVB-H Free-TV and radio	- These are free-TV channels, which are available to consumers without payment. They can be new channels or simulcasts of existing DVB-T channels. - Service is distributed through the IPDC/DVB-H network. - This service can yield advertising revenue for its broadcaster.
DVB-H Pay-TV subscription	- These are short-term subscriptions of pay-TV channels, e.g. a single sport or movie channel, or a channel package. - Service is distributed through the IPDC/DVB-H network.
DVB-H Pay-TV Pay-per-View	- These are subscriptions of single pay-TV programmes, e.g. sports events. - Service is distributed through the IPDC/DVB-H network.
3G Streaming Video-on-Demand	- These are video-on-demand service distributed through the mobile data network. These can be e.g. short video clips or complete TV shows.

Interactive services

Interactive services are those that utilise the interactivity path. Note that apart from the applications and filecasting service, these services more or less exist independently of DVB-H, and are therefore considered only as far as they can bring incremental usage. Table 5 below gives a complete listing and a short description of each service.

Table 5: Interactive services included in the model.

Service name	Description
Interactive: Communications	Ordinary mobile communications, i.e., voice, SMS and MMS, triggered by mobile television watching. Can be e.g. person-to-person communications or free interactions with mobile TV content.
Interactive: Premium SMS	Interactions with mobile TV content that cost more than normal SMS. Can be e.g. a chat programme or voting.
Interactive: Personalisation	Sales of personalisation items related to mobile TV content. Can be e.g. ringtones, operator logos, wall-papers etc.
Interactive: E-commerce	Sales of tangible or intangible goods related to mobile TV content, e.g. MP3's or DVD's.
Interactive: Applications and filecasting	Sales of application or file downloads through the IPDC/DVB-H network. Can be e.g. games or news feeds.

Handset sales

A mobile operator type of service operator can distribute DVB-H handsets by selling the phones either directly or by bundling the handset with a mobile subscription (only for WCDMA capable handsets). For simplicity, we assume that broadcaster or content aggregator type of service operators do not sell handsets.

We consider only the incremental cash flows from selling DVB-H enabled handsets compared to selling regular WCDMA handsets. Table 6 shows the parameters we use for modelling handset sales.

Table 6: Parameters related to handset sales.

Parameter	Range
Proportion of consumers buying their DVB-H handsets from the service operator.	60% - 85% for mobile operators. 0% for broadcasters.
Proportion of bundled handsets of all handsets sold in 2007.	35% - 75%, annual growth factor 80% - 110%.
Average length of handset replacement cycle.	18 - 36 months.
Average extra cost price (for a service operator) of a DVB-H handset compared to a conventional WCDMA phone in 2007.	EUR 20 - EUR 50, annual reduction factor 50% - 65%.
Average extra retail margin of a DVB-H handset compared to a conventional WCDMA phone in 2007.	EUR 20 - EUR 50, annual reduction factor 50% - 70%.
Average extra retail margin or operator subsidy of a bundled DVB-H handset compared to a conventional WCDMA phone in 2007.	EUR 0 - EUR 30, annual reduction factor 50% - 70%.

For simplicity, we assume that when a service operator sells handsets directly to its customers, it purchases them from vendors during the same year it sells them. We can then calculate just the gained extra retail margins.

On the contrary, when a service operator sells bundled phones, it purchases them from the vendors during the same year it gives them to customers, but customers pay the phone in 24 consecutive monthly instalments. Roughly, the operator then gets 25% of the phone price plus the retail margin (or minus the subsidy) during the same year, 50% on the next year, and 25% on the year after. Here we assume that there would be no credit risk in handset bundling.

We approximate the replacement sales using the average replacement cycle for the operator's whole DVB-H customer base, so that 50% of the customers replace their handsets during the year the average cycle length indicates, and 50% on the next year.

Advertising sales

Forecasting the flow of advertising money is difficult. The total advertising spending in Finland grows slowly, following roughly the GDP. Table 7 below shows that, while TV advertising is growing at the same pace as the total mass media advertising market, Internet advertising is currently experiencing double-digit growth.

Table 7: Media advertising 2004 - 2005 (Mainonnan neuvottelukunta 2006, 2007).

	2004	2005	2006	Change 2005-2006
TV advertising, MEUR	226.5	230.7	242.9	+5 %
Radio advertising, MEUR	47.8	47.2	46.8	-1 %
Internet advertising, MEUR	25.4	36.1	47.1	+30 %
Electric media, total, MEUR	**299.7**	**314.1**	**336.8**	**+7 %**
All media, total, MEUR	**1,151.5**	**1,188.9**	**1,232.9**	**+4 %**

Mobile TV advertising will likely have to compete with other media for the same 'advertising pie'. In our mind, the pie can grow, i.e., new advertising money can be available in two ways: either if there are each year more new businesses starting than old ones going out of business, or advertising spending of existing businesses increases overall for some reason in real terms.

Therefore, mobile TV advertising euros could be away from other media; if mobile TV advertising is away from the conventional TV channel, or other forms of media under the same media group, then the gain would be zero. For simplicity, in the modelling we consider the advertising cash flow as incremental and not cannibalising other functions of a media group.

We assume that only simulcast free-TV channels get mobile TV advertising money; pay-TV is free of advertisements. We also assume that advertising minutes can be sold separately for mobile TV, i.e., the advertising on mobile TV can differ from the original DVB-T broadcasts. Moreover, we assume that only broadcaster type of service operators would put up free-TV channels. Therefore, advertising affects only broadcaster type of service operators.

We set total TV advertising in 2007 to MEUR 250 and have it grow 4% annually. We make a very rough approximation that DVB-H would get 2% of the total TV advertising spending for every 10 percentage points of population with DVB-H handsets. In other words, if 10% of population has DVB-H handsets, the free mobile-TV channels get in total 2% of the total TV advertising spending; 4% for 20% of population etc. We then multiply the total mobile TV advertising with the broadcaster’s market share to get the annual advertising revenue.

3.5.3 Operating models

The generic business ecosystem we described in Section 3.2.3 enables the mapping of different types of service operators and business models together. We call these different combinations of operator type and business model operating models.

The primary source of money for the ecosystem is the end user, i.e., the consumer. Consumers finance the whole ecosystem directly and/or indirectly by handing over money for e.g. handsets, payable mobile TV services, TV fees, and goods advertised on mobile TV. The ecosystem then channels the money to each player in accordance to e.g. its position in the value network, the risk it bears, and its negotiation power. The ecosystem is viable only if it manages to collect enough money from consumers to finance the whole service delivery network in the long term.

Then, for a service operator the money flows, namely revenues and costs, are based on its operating model. In the calculation model, we specify an operating model by using three key parameters:

1. Is the service operator a mobile operator or a broadcaster?
2. Does the service operator pay for DVB-H capacity?
3. Does the service operator pay for rights to TV programming?

If the service operator is a mobile operator, it can be either an MNO or an MVNO. In both cases, it has a billing system in place and a direct billing relationship with its mobile subscribers.

If the service operator is a broadcaster or other content aggregator, it can either outsource its pay-TV billing to mobile service operators, or handle pay-TV billing in-house using other sales methods. In both cases, billing for interactive services goes through mobile operators.

If the service operator pays for DVB-H capacity directly, it pays a monthly sum to Digita for each TV channel. If there are several service operators providing capacity for the same channel, Digita will split up the capacity bill evenly between them. If the service operator does not pay directly for the capacity, it indirectly participates in its financing through a revenue sharing scheme. One service operator can buy at maximum 1/3 of the total capacity.

If the service operator pays for rights to TV programming directly, it pays a monthly sum per subscriber per channel. If the service operator does not pay directly for the programming, it indirectly participates in its financing through a revenue sharing scheme.

If the answer to questions two and three is no, the service operator merely resells other players' TV channels and channel bundles. The model allows us to determine the case on service level, so that a mixed model would be possible.

Using the three above parameters and applying the work of Kivisaari (2006), Digital Terrestrial Television Action Group (DigiTAG) (2005), and European Broadcasting Union (EBU) (Weck and Wilson, 2006), we create in total seven different operating models for the analysis:

1. MNO approach.
2. MVNO approach.
3. Broadcaster approach with outsourced billing.
4. Broadcaster approach with in-house pay-TV billing.
5. Pay-TV broadcaster with outsourced billing.
6. Co-operation approach, MNO with broadcasters.
7. Co-operation approach, MVNO with broadcasters.

Operating model 1: MNO approach

In this model, service operator is a vertically integrated mobile operator, i.e., a service operator with its own mobile network. It handles four roles in the ecosystem: broadcaster, rights issuer, mobile service operator, and mobile network operator. In EBU's terminology, this model is "Mobile telecom operator-led approach with broadcast network operator."

Figure 8 below illustrates the model set up. The service operator performs the roles on light blue background, and Digita the roles on light green background. Table 8 below describes the numbered payment flows.

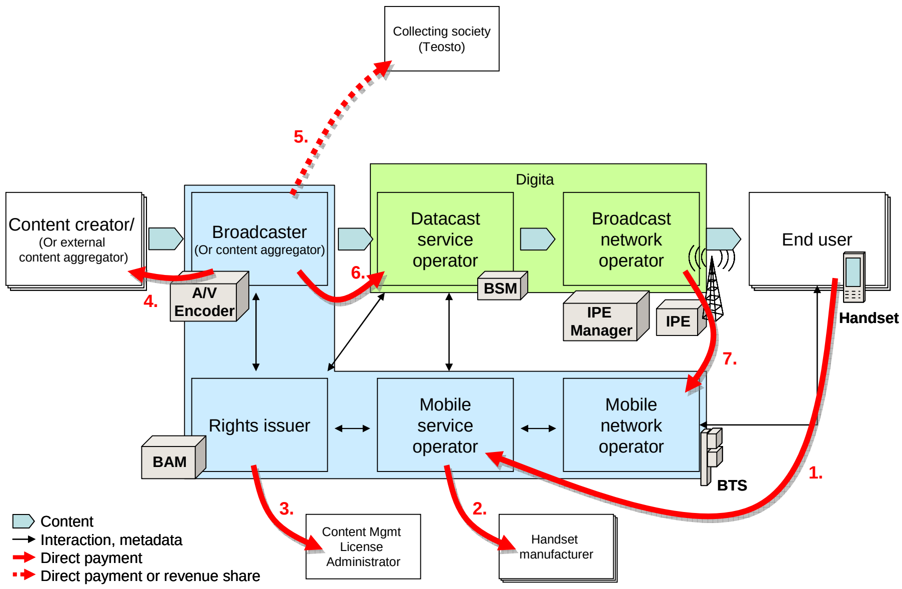

Figure 8: Roles and payment flows in MNO approach.

Table 8: Description of payment flows in MNO approach.

Payment flow	Description
1. End user -> Service operator	End users pay for TV services, interactive services, and handsets.
2. Service operator -> Handset manufacturer	Service operator pays for handsets it sells to end users.
3. Service operator -> CMLA	Service operator pays “Service Provider Key and Certificate Issuance Fee” to CMLA.
4. Service operator -> Content creator	Service operator purchases rights for complete TV channels or separate TV programming and interactive content.
5. Service operator -> Collecting society	Service operator pays fees for the copyrighted music in the TV programming and interactive services.
6. Service operator -> Digita	Service operator pays for DVB-H transmission capacity.
7. Digita -> Service operator	Digita pays leases for network infrastructure.

Operating model 2: MVNO approach

In this model, service operator is an MVNO. It provides mobile services and SIM cards to its subscribers, but leases mobile network access from an MNO. In EBU’s terminology, this model is the same as model 1, i.e., “Mobile telecom operator-led approach with broadcast network operator”.

Figure 9 below illustrates the model. The service operator performs the roles on light blue background, and Digita the roles on light green background.

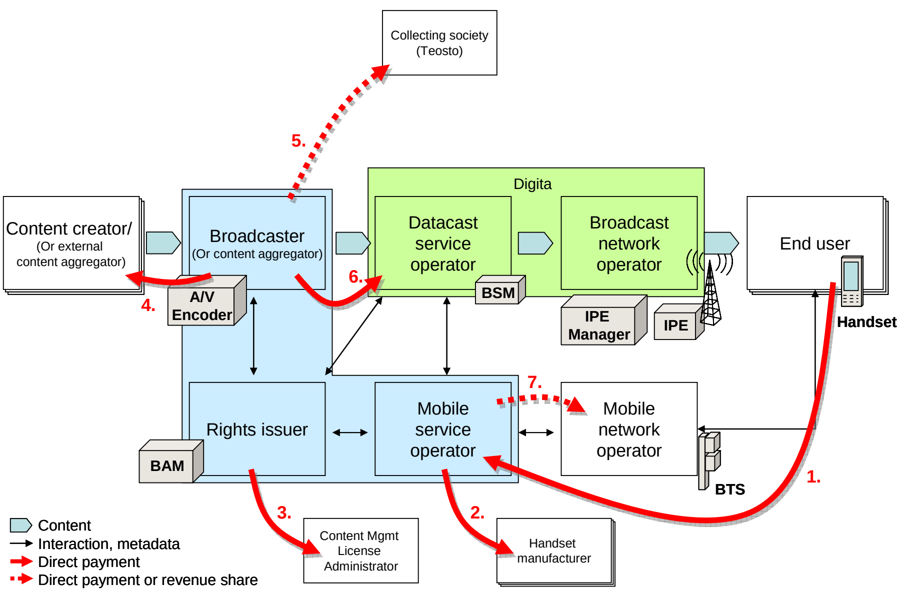

Figure 9: Roles and payment flows in MVNO approach.

The payment flows in this model are the same as in model 1 (shown in Table 8 above), except that an MVNO gets no infrastructure leases from Digita, and that an MVNO has to pay to a mobile network operator for the access to its mobile network to deliver the interactive services (payment flow #7 in Figure 9).

Operating models 3, 4, and 5: Broadcaster approach

In these models, service operator is a broadcaster that does not provision mobile connectivity or sell handsets. In EBU's terminology, these models closest resemble the "Content aggregator-led approach".

In models 3 and 4, the broadcaster provides both free-TV and pay-TV channels. In model 5, the broadcaster provides only pay-TV channels. In all three cases, the broadcaster provides also interactive services.

In models 3 and 5, broadcaster outsources all end user billing to mobile operators. We label this approach as indirect broadcaster approach. In model 4, broadcaster performs end user billing for TV services in house. We label this approach as direct broadcaster approach. However, we assume that all interactive services always go through mobile operator billing.

Figure 10 below illustrates the model. The service operator performs the roles on light blue background, and Digita the roles on light green background. Table 9 below describes the payment flows.

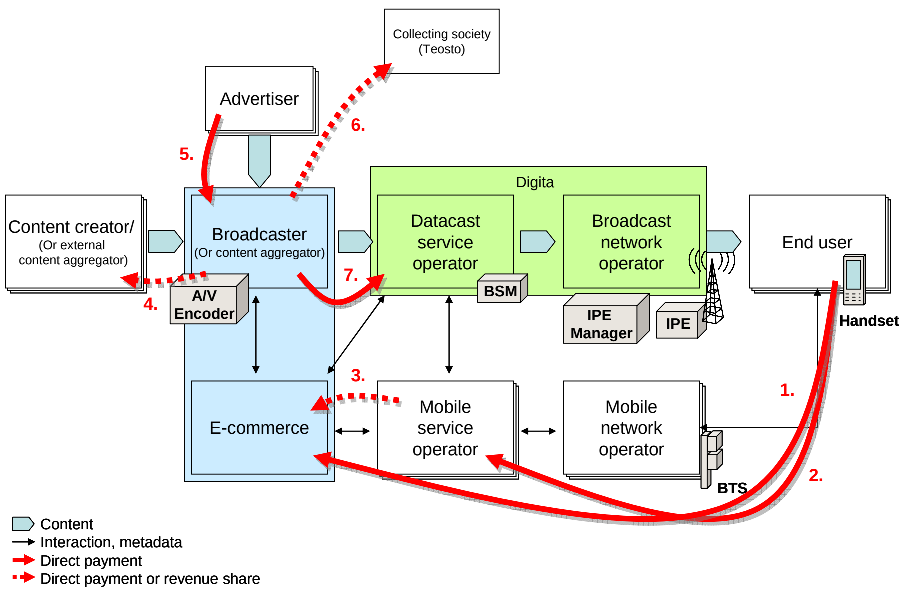

Figure 10: Roles and payment flows in broadcaster approach.

Table 9: Description of payment flows in broadcaster approach.

Payment flow	Description
1. End user -> Service operator	Model 4 only: End users pay for TV services directly.
2. End user -> Mobile service operator	Models 3 & 5: End users pay for TV services and Interactive services through cellular operators. Model 4: End user pay for interactive services through cellular operators.
3. Cellular mobile operator -> Service operator	Mobile service operator relays the service revenues to service operator after taking its share for end user billing.
4. Service operator -> Content creator	Service operator purchases rights for complete TV channels or separate TV programming and interactive content.
5. Advertiser -> Service operator	Model 3 & 4: Advertisers pay for advertising minutes on channels simulcast over DVB-H.
6. Service operator -> Collecting society	Service operator pays fees for the copyrighted music in the TV programming and interactive services.
7. Service operator -> Digita	Service operator pays for DVB-H transmission capacity.

Operating model 6: Co-operation approach, MNO

In this model, a MNO takes care of pricing, sales, and marketing of services provided by broadcasters. Broadcasters buy the capacity and rights for TV programming and interactive content.

Figure 11 below illustrates the model. The service operator performs the roles on blue background, and Digita the roles on light green background. Table 17 below describes the payment flows.

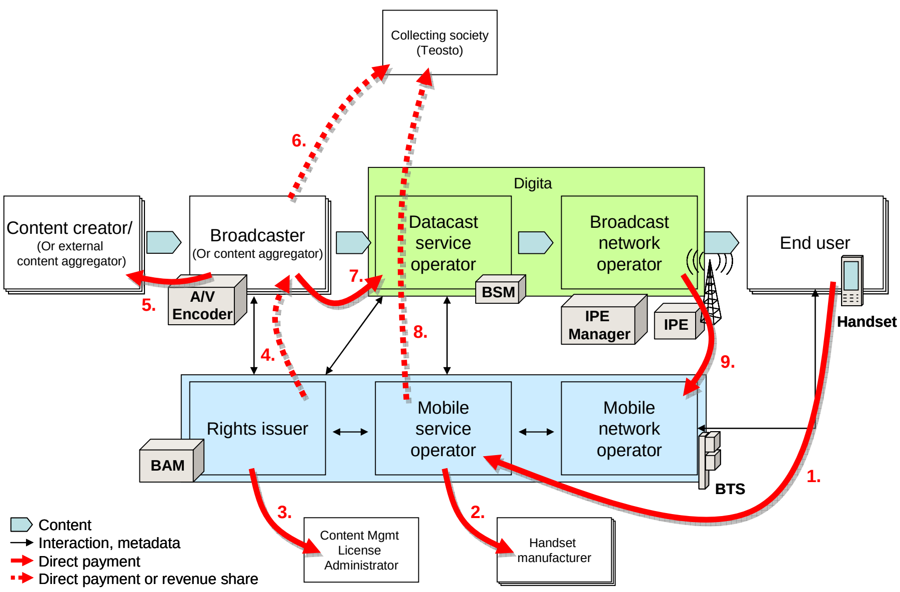

Figure 11: Roles and payment flows in co-operation approach, MNO.

Table 10: Description of payment flows in new player model.

Payment flow	Description
1. End user -> Service operator	End users pay for TV services, interactive services, and handsets.
2. Service operator -> Handset manufacturer	Service operator pays for handsets it sells to end users.
3. Service operator -> CMLA	Service operator pays “Service Provider Key and Certificate Issuance Fee” to CMLA.
4. Service operator -> Broadcaster	Service operator relays revenue to broadcaster, after taking its share.
5. Broadcaster -> Content creator	Broadcaster purchases rights for complete TV channels or separate TV programming and interactive content.
6. Broadcaster -> Collecting society	Broadcaster pays fees for the copyrighted music in the TV programming. Copyright fees for interactive services go through mobile operators.
7. Broadcaster -> Digita	Broadcaster pays for DVB-H transmission capacity.
8. Digita -> Service operator	Digita pays leases for network infrastructure.

Operating model 7: Co-operation approach, MVNO

In this model, a MVNO takes care of pricing, sales, and marketing of services provided by broadcasters. Broadcasters buy the capacity and rights for TV programming and interactive content. This model is then the same as model 6, except that the MVNO pays to a MNO for access to a mobile network, and the MVNO does not get infrastructure leases from Digita.

3.5.4 Revenue sharing

We model the revenue sharing scheme for each distinct service using a revenue sharing matrix. The composition of the revenue sharing matrix for a mobile operator based service operator differs somewhat from that for a broadcaster based service operator. Note that the revenue sharing is based on consumer prices excluding VAT 22%. The revenue sharing percentages are rough approximations.

Table 11 below shows the revenue sharing scheme for mobile operator based models, i.e., models 1, 2, 6 and 7. The ‘external content parties’ column approximates revenue sharing to external broadcasters or other content aggregators, which provide programming and content. If the service operator takes the broadcaster role (models 1 & 2), and buys the programming rights directly, there is no revenue sharing between these parties. If the service operator does not take the broadcaster role (models 6 & 7), an external content aggregator pays for the programming and capacity, and takes a share of the revenue.

If the service operator is an MVNO, it has to lease mobile network access from an MNO. We can approximate these network-leasing payments as revenue sharing, although this might not be the standard practice in real world situations.

Table 11: Revenue sharing for operating models 1, 2, 6, and 7.

Models 1 & 2: A = 0%.
Models 6 & 7: A = 70…85%
Models 1 & 6: B = 0%
Models 2 & 7: B = 5...10%

Service / Player	External content parties	Collecting society	External mobile network operator	Broadcast network operator (Digita)
Channel package	A	1.5%...3%		
Pay-TV subscription	A	1.5%...3%		
Pay-TV Pay-per-View	A	1.5%...3%		
Video-on-Demand	65%	3%	B	
Communications			B	
Premium SMS	80%		B	
Personalisation	70%	8%	B	
E-commerce	70%	6%	B	
Applications & filec.	65%			10%

Table 12 below shows the corresponding revenue sharing scheme for broadcaster based operating models, i.e., models 3, 4, and 5. The ‘external content creators’ column approximates the costs of video-on-demand and interactive content, although this content might not be sold on revenue sharing basis in real world situations.

Table 12: Revenue sharing for operating models 3, 4, and 5.

Model 4: C = 0%
Models 3 & 5: C = 15...30%
Models 3, 4 & 5: D = 15…30%

Service / Player	External content creators	Collecting society	External mobile service operators	Broadcast network operator (Digita)
Channel package		1.5%...3%	C	
Pay-TV subscription		1.5%...3%	C	
Pay-TV Pay-per-View		1.5%...3%	C	
Video-on-Demand	30%	6%	C	
Communications			100%	
Premium SMS			D	
Personalisation	30%	8%	D	
E-commerce	30%	6%	D	
Applications & filec.	30%		D	10%

Service operator gets the remainder after the revenue sharing. For instance, Video-on-Demand revenue for a broadcaster type of service operator with outsourced billing (model 3) is:

$$100\% - 30\% - 6\% - C = 34\ldots49\%.$$

We use ranges for the variables A, B, and C to enable simulating the effect of small changes in revenue sharing on the total business case. The fixed percentages are rough estimates for the services we consider less important in the first years of mobile TV.

Note that in real world, there can be threshold arrangements, so that in addition to the revenue sharing, content owner is guaranteed a given level of compensation regardless of the actual service revenue. According to an expert we interviewed, this is common in the mass media field. Our calculation model, however, assumes that there are no such threshold arrangements.

The copyright fees payable to Teosto for pay-TV channels are set to range from 1.5% to 3%, following the current practice for cable-TV operators – according to Teosto's (2007) price lists, cable-TV operators must hand over 1.5% of their after-tax pay-TV revenues to Teosto. We assume that mobile TV programming can be more audio oriented than conventional TV programming, hence it can have a higher amount of music.

Moreover, Teosto takes 12% of after-tax revenue for selling a ringtone or for a downloaded MP3 song. If half of the e-commerce revenue would consist of MP3 sales, half of the revenue would be subject to the 12% fee, hence resulting in 6% share of the total. We can use a similar figure for video-on-demand, since the video material can hold copyrighted music. As for personalisation, if 70% of the sales would consist of ringtones etc., Teosto's share would be 8%.

3.5.5 Operational expenditure

In the calculation model, we consider only incremental operational expenditure (OPEX), i.e., the new outgoing cash flows that result from the business case of provisioning DVB-H mobile TV services.

To get the total OPEX contribution of the business case, we then start from pieces and model the following OPEX categories:

- Equipment and software licences and maintenance outsourcing
- Sales, marketing, and customer acquisition
- Customer care
- Charging and billing
- Service management and service development
- Regulation
- DVB-H capacity lease
- TV programming

The numbers given under the category definitions are based on either expert interviews or our own estimates. If not specified otherwise, all variable ranges are uniformly distributed.

Equipment and software licences and maintenance outsourcing

This OPEX category includes expenses paid by the service operators to the BAM equipment vendor as well as the associated DRM fees paid to a DRM certifier. This cost category is applicable only to the mobile operators (models 1, 2, 6, & 7).

We assume that the service operators acquire the BAM through application renting, so that the rental includes all hardware, software licences, and maintenance. The rental is set to range from EUR 1 to EUR 5 per active subscriber per year. We then calculate the BAM expense as the rental payment times the annual average number of channel package subscribers.

Application rental disables depreciation tax shields, which would be available if the service operator purchased the machinery directly and included it in the capital expenditure. However, it is probable that mobile TV service business will not make a profit during the first years of operation, and hence would not bring about incremental corporate taxes either, making the depreciation tax shields useless anyhow.

For using the BAM, the service operator must pay a quarterly fee to Content Management Licence Administrator (CMLA). CMLA is a licensing and compliance entity formed by Intel, Nokia, MEI/Panasonic and Samsung to provide an implementation of the Open Mobile Alliance (OMA) Digital Rights Management (DRM) version 2.0 interoperability specifications (CMLA 2007a). CMLA assures content providers that each licensed rights issuer (with BAM equipment) follows the specifications.

The name of the quarterly fee to CMLA is “Service Provider Key and Certificate Issuance Fee”, and its size depends on the number of active subscribers. Table 13 below shows the fees for different subscriber quantities.

Table 13: Quarterly CMLA fees, USD (CMLA 2007b).

Active subscribers	Fee
1 – 5,000	$1,500
5,001 - 100,000	$2,500
100,001 - 250,000	$4,500
250,001 - 1/2 Million	$7,000
1/2 – 1 Million	$9,450
1 - 2 Million	$12,750
2 - 4 Million	$17,225
4 - 8 Million	$23,250

We multiply the quarterly fee by four and by the average number of channel package subscribers to get the total cost per year. In converting the CMLA fee to EUR, we assume a constant currency rate of EUR 1 = USD 1.3 throughout the study period.

Sales, marketing, and customer acquisition

This category includes costs that result from sales, marketing, advertising campaigns, and other sales promotion activities, as well as costs related to handset bundling.

For simplicity, we model everything except handset bundling as one annual lump sum, so that we specify the initial sum for 2007 marketing spending, and then an annual development factor as a percentage. The size of marketing spending has an effect on the service demand, as we later describe in the section covering the environmental scenario.

The method is by no means accurate, but we do not have sufficient data to forecast the operators’ sales and marketing efforts and behaviour. Table 14 below shows the marketing spending in 2007 and annual development factors we use for the different operating models.

Note that on average, mobile operators spend less each year on marketing mobile TV, as we expect them to have new services taking up focus and share of their limited marketing budgets in the future.

In contrast, we expect broadcasters to spend on average the same sum each year as we expect mobile TV to become an important distribution channel for them.

Table 14: Marketing spending parameters

Operating model	**Marketing spending 2007, MEUR**	**Annual development, %**
1. MNO approach	0.5 - 3	80% - 110%
2. MVNO approach	0.2 - 2	80% - 110%
3. Broadcaster approach with outsourced billing	0.5 - 2	90% - 110%
4. Broadcaster approach with in-house pay-TV billing	0.5 - 2	90% - 110%
5. Pay-TV broadcaster with outsourced billing	0.5 - 2	90% - 110%
6. Co-operation approach, MNO with broadcasters	0.4 - 2	70% - 100%
7. Co-operation approach, MVNO with broadcasters	0.4 - 2	70% - 100%

To calculate handset bundling costs, we first multiply the annual number of handsets sold by the annual share of bundled handsets, and then multiply the result by the annual extra cost price of a DVB-H-enabled phone compared to a conventional WCDMA phone. We specify the above-mentioned parameters for 2007, and then scale them using respective annual development factors. Note that only mobile operators do handset sales and handset bundling.

The share of bundled DVB-H handsets is from 35% to 75% in 2007, and its annual development is from 80% to 110%. The share of bundled handsets is limited to 100%.

The extra cost price of a DVB-H handset is from EUR 20 to EUR 50 in 2007, and its development factor is from 50% to 65%, halving the cost price each year from 2008 onwards.

Customer care

This category includes customer service related costs, which can be for instance due to running help desk functions and handling customer complaints. We model these costs through labour costs.

We estimate the number of extra customer care personnel needed in 2007 and then multiply it with a growth factor for to get the following years. We get the annual spending by multiplying the number of personnel by the annual cost of labour.

We assume the number of needed extra customer care personnel to be small for mobile operators, as they already have help desk functions. Note that a broadcaster that outsources all billing to a mobile operator needs no or very little customer service functions.

The number of needed new personnel is then larger for a broadcaster type of service operator that does not outsource billing and does not have sufficient existing consumer service operations.

Table 15 below shows the number of personnel for different operating models. We set the average total cost of labour throughout the study period to be EUR 50,000 per year per person. The annual development factor ranges from 100% to 110%.

Table 15: Customer care parameters

Operating model	Extra customer care personnel 2007
1. MNO approach	0.2 - 1
2. MVNO approach	0.2 - 1
3. Broadcaster approach with outsourced billing	0 - 0.2
4. Broadcaster approach with in-house pay-TV billing	2 - 4
5. Pay-TV broadcaster with outsourced billing	0 - 0.2
6. Co-operation approach, MNO with broadcasters	0.2 - 1
7. Co-operation approach, MVNO with broadcasters	0.2 - 1

Charging and billing

If a broadcaster type of service operator does not outsource billing to a mobile operator, it has to arrange charging and billing otherwise to sell its channel packages. This category includes costs associated with usage metering, data collection, and billing, as well as issuing rights objects or handling other means of conditional access.

We model this with a monthly cost per active subscriber ranging from EUR 0.20 to EUR 0.60. Note that the billing for interactive services goes through the mobile service operators in any case.

Service management and service development

This category includes costs related to e.g. having a responsible service manager to take care of the project and relations to other companies in the value network. The category also includes the service development engineers and other people participating in designing, implementing, and running the services.

We model this category by using a lump sum for service management in 2007 and an annual development factor. For the service development part, we use the number of extra personnel needed in 2007, an annual development factor, and the annual cost of labour.

The service management lump sum in 2007 ranges from EUR 50,000 to EUR 150,000, and its annual development factor ranges from 70% to 110%. Number of extra personnel needed in 2007 ranges from 2 to 6, and its development factor ranges from 70% to 110% as well. The average annual total cost of labour throughout the study period is set to EUR 75,000.

Regulation

This category consists of possible costs related to collecting and reporting information to the regulator, and possible costs due to changes in regulation. We approximate the costs with a small fixed lump sum per year, EUR 20,000. The effect of this category on the business case is limited, and it is included essentially for caution.

DVB-H capacity lease

This category includes the DVB-H network capacity payments to Digita. For simplicity, we assume that all capacity is nationwide. The price is then same for all TV channels.

We model the capacity costs by multiplying the price of one channel by the number of channel capacities bought by the service operator. If there are many service operators provisioning the same channel packages, we divide the capacity bill for those channels by the number of service operators. We can set the number of service operators sharing a channel package separately for each year during the study period.

The price of channel capacity follows the network coverage, as Digita's CAPEX and OPEX costs increase in proportion to the number of transmitters and repeaters in use.

We assume the network's population coverage to be 40% at the end of 2007, and from 55% to 78% at the end of 2011. We assume the maximum number of channels on air to be 21 during 2007 and 2008, and 35 between 2009 and 2011. One player can buy maximum 1/3 of the total capacity, i.e., from 7 to 11 channels, unless several players jointly finance some of the channels. We cover the cost of capacity in Section 3.3.1.

If a service operator does not pay directly for capacity, it does not have capacity related costs. Digita then gets money from broadcasters, which get money from the service operator through revenue sharing.

TV programming

This category includes costs related to acquiring programming for the channels/channel packages. If the service operator does not pay directly for the content, it will not have programming expenses and the money will go to content parties through revenue sharing.

According to an expert from the TV field, broadcasters will likely acquire the programming on a whole channel basis instead of single programmes. The programming cost is based on the number of subscribers. In the beginning, the programming can be even free, as media houses compete for market shares, and several extra channels can be bundled together with one quality channel.

We model the programming costs by using an average cost per channel for each channel package. We then multiply it by the number of channels in each channel package. We set the monthly average cost per channel per subscriber to range from EUR 0.20 to EUR 0.50. We assume that simulcasts bear no additional programming costs when showed on DVB-H mobile TV.

3.6 Environmental scenario

In this section, we describe how we model the target market in terms of network dimensioning, potential service usage, and market penetration over time.

3.6.1 Network dimensioning

The focus of this study is on the service side of mobile TV, but we need estimates for the cash flows resulting from site and transmission link leasing. Hence, for the purpose of this thesis, we can conduct a very rough network dimensioning through comparison between area types and existing broadcast network infrastructure.

Geography and population density

Finland, as a typical Nordic country, has a small population compared to the total land area and hence a low population density. Table 16 below shows the division of the total land area of a typical Nordic country into "dense urban", "urban", "suburban", and "rural" area types applying the figures from Smura et al. (2006). Smura et al. have also studied the division of the total mobile telecoms traffic between area types.

Table 16: Division of land area and mobile traffic (Smura et al. 2006).

Area type	Typical Nordic country, size of area, km^2	Share of total area, %	Finland, size of area, km^2	Share of total mobile tele-coms traffic
Dense urban	17	0.005%	20	15%
Urban	264	0.08%	313	50%
Suburban	3,300	1%	3,910	25%
Rural	264,000	80%	312,800	10%
Total	330,000	100%	391,000	100%

The definition of urban area varies in different sources. Statistics Finland (2006a) reports that urban settlements in Finland covered 2.2% of total land area and 82.3% of the population in 2000, whereas the Statistic Division of United Nations reports that only 62% of Finnish population lived in urban areas in 2004.

We can use the estimate of the Ministry of Transport and Communications (2005b), according to which 50% of the population lives in an area that covers

0.4% of the total land area, and that the most densely populated 1% of land area holds 71% of people.

Therefore, we could say that building the network in the largest cities alone will easily provide the required 40% population coverage. After that, people start to be located less densely.

Moreover, during the busy hours of weekdays, the cities become even more populated, since a lot of people commute from surrounding communities. The interviewed experts see the commuters as a potential user group for mobile TV, and building coverage over the major highways and roads connecting the largest cities could make sense.

Comparison with DVB-T

Figure 12 below shows the largest functional urban regions in Finland in 2000 (left side) and Digita's main DVB-T broadcast towers (right side).

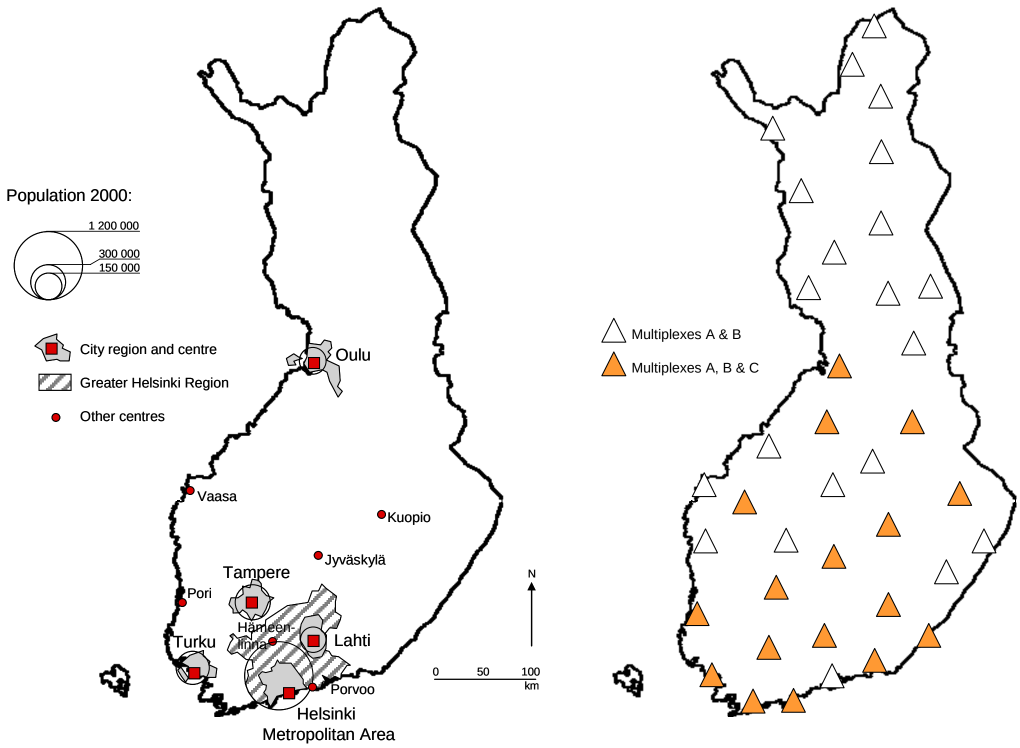

Figure 12: Urban regions (redrawn, OECD 2003) and Digita's DVB-T broadcast towers.

All broadcast towers transmit the multiplexes A and B. The shaded broadcast towers transmit also the multiplex C, which includes pay-TV channels and some smaller free-TV channels. DVB-T population coverage is 99.9% for multiplexes A & B, and from 78% to 83% for multiplex C. (www.digitv.fi)

By comparing the two maps in Figure 12, we can see that the multiplex C is available mainly in the most densely populated areas. According to the DVB.H spectrum licence, the DVB-H population coverage would be at maximum around 75% and its bulk would consist of the largest cities and the major roads connecting them. Areas with a low population density will likely be left outside.

During 2007, Digita will have in total 28 sites broadcasting multiplex C: 17 main transmitters and 11 gap-fillers. These main transmitter towers have further 61 gap fillers, which are currently not transmitting multiplex C.

From the above information, we can conclude that the eventual population coverage will be from 40% to 80%. This means that if network expansion beyond the 40% requirement is undertaken, it will supposedly follow roughly the same areas as DVB-T multiplex C covers during 2007, starting with the densest areas.

Infrastructure leasing

Digita owns a vast network of broadcast towers and transmission links, but DVB-H indoor coverage requires a large number low-power transmitters. The hybrid solution of using both broadcast towers and cellular BTS sites is the soundest option, but requires Digita to lease the BTS sites from mobile network operators.

Figure 13 below illustrates the structure of IPDC/DVB-H transmission network. The Internet Protocol Encapsulators (IPE), which encapsulate the IP packets into MPEG transport stream, are connected to the IP multicast network by backbone links. The transmitters are connected to the IPE by a backhaul link. Repeaters/gap fillers do not need transmission links as they listen to the actual radio transmission from the main transmitter and retransmit it.

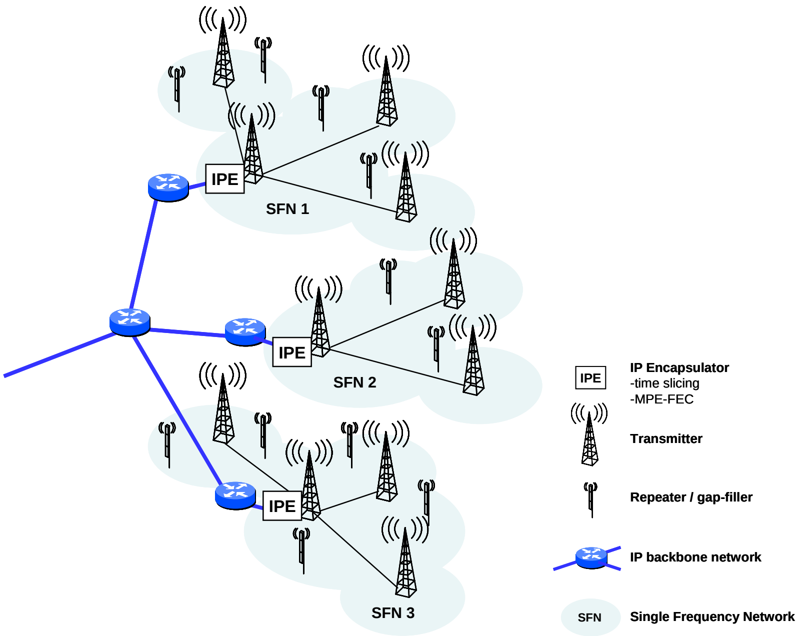

Figure 13: IPDC/DVB-H transmission network structure (applied Hoikkanen 2006b).

Note that a mobile network operator can probably make network infrastructure leasing deals with Digita even if it self chooses not to start provisioning/reselling IPDC/DVB-H services. However, staying out could slow down the adoption of handsets, and thus slow down the expansion of the DVB-H network beyond the 40% population coverage, affecting the eventual number of leased sites. Therefore, the infrastructure leasing revenues for a mobile network operator can be partly non-incremental and partly incremental cash flows resulting from the business case. For the sake of clarity when presenting results, we give the NPV of these cash flows separately from the service cash flows.

To make an estimate of the lease payments, we must consider the network-building schedule, the eventual total number of transmitter and gap filler sites to be used, the proportion of leased sites, and the size of the lease payments itself.

At the outset, we know that the required number of transmitters for DVB-H is considerably larger than for DVB-T, but much lower than for GSM or WCDMA (Hoikkanen 2006a). We know that for 78% population coverage in DVB-T, Digita uses 17 main transmitters and 11 gap fillers. The WCDMA network on the other hand may require around 2,200 sites for 60% - 70% coverage (Ministry of Transport and Communications 2005b).

Digita has already announced that the network has been built to cover parts of the capital region, Turku, and Oulu, resulting in initial population coverage of 25%. This will be expanded to around 40% by the end of 2007, when Tampere region is included.

Kauppalehti (2006b) quotes Tom Granvik, the CEO of Rohde & Schwarz Finland, saying that slightly over ten transmitters would be sufficient in the capital region in the beginning. From the simulations presented by Silvennoinen (2006) and based on the opinion of an IPDC/DVB-H service system expert, we conclude roughly that from 15 to 20 sites (transmitters and repeaters) could be adequate in the capital region in the final setting. We expect both Turku and Oulu to have from 5 to 10 sites. From these numbers we conclude that the first three areas need roughly in total from 25 to 40 sites.

According to Hoikkanen (2006a), the number of needed repeaters is roughly twice the number of transmitters. This would imply using from 9 to 14 transmitters and from 18 to 28 repeaters in the first three cities.

The type, transmission power, and number of DVB-H transmitters can vary according to the land area type. In dense urban areas, characterised by tall concrete buildings, many low power transmitters are needed to provide plausible in-door coverage, whereas few high-power transmitters can be enough for highways and rural areas with open terrain. Therefore, the average “cell” ranges of DVB-H transmitters are different for each area type. According to Smura et al. (2006), the area type specific DVB-H cell ranges are as follows:

- Dense urban 1.5 km,
- urban 2.5 km,
- suburban 10 km, and
- rural 30 km.

These ranges are based on providing a plausible indoor coverage. Large city centres will need significantly more sites than less dense suburbs and rural areas. For large rural areas and roads, providing outdoor coverage can be sufficient, which would expand the cell range even further especially with directional antennas.

We can then estimate that for every main transmitter Digita uses for DVB-T multiplex C, it would need from 10 to 15 DVB-H sites (transmitters and repeaters) for providing 78% population coverage, i.e., from 10*17 = 170 to 15*17 = 255. This would mean from 57 to 85 transmitters and twice as many repeaters. Note that these figures are not based on actual network measurements and can be unrealistic.

Since Digita owns 17 transmitters and around 70 gap-fillers in these areas, it would need to lease approximately from 50% to 65% of the sites to achieve 78% population coverage. We can use this figure as an estimate for the average proportion of leased sites.

The annual site leasing revenue for a mobile network operator is then calculated as follows:

$$M * [(N_{txi} + 2N_{Txi}) * L * L_{Tx}) + N_{Txi} * L * L_{tr}]$$

Where:

M = mobile network operator's market share of leased sites, %.

N_{Txi} = number of transmitter sites in use in year i.

L = average proportion of transmitter and repeater sites leased.

L_{Tx} = annual site lease, EUR.

L_{tr} = annual transmission link lease, EUR.

The annual numbers of transmitter sites (N_{txi}) is acquired by scaling the annual network population coverage by number of sites required for 78% coverage. For example, we know from the licence conditions that the population coverage at the end of 2007 must be 40%, and thus get:

$$N_{Tx2007} = 40\% / 78\% * 57…85 \sim 29…44$$

In the calculations, we set the eventual network population coverage for year 2011 to range from 55% to 78%.

3.6.2 Service market dimensioning

Forecasting the potential market size and service penetration is among the most critical tasks in the bottom-up service modelling approach, since most revenues and possibly a significant part of operational expenditure are dependent on the number of users. To estimate the market size and revenues for the IPDC/DVB-H mobile TV services, we need to forecast two penetrations:

1. How many people will buy a DVB-H enabled handset, and
2. How many of these people will subscribe to the services?

Intuitively the first side of the problem determines the size of the potential service market, and the second side determines the reached service penetration. For the potential market, the upper limit will be the total population of Finland, but for the service penetration, it will effectively be the DVB-H network coverage.

Especially in the first years, people living and working outside the network coverage are likely to have little motivation to invest hefty sums to a DVB-H enabled handset. This limitation can become obsolete if the extra price of the DVB-H feature becomes negligible in some point of time. Here the word price implies both monetary cost and inconvenience cost of carrying a bulky device.

The initial limiting natural factors for service operator revenues are then in descending order: population size, network coverage, handset penetration, and payable service penetration.

3.6.3 Handset adoption

Intuitively, the size of the service market equals the number of DVB-H enabled phones sold to the public. We can then model the potential service market size as the outcome of an innovation diffusion process, so that the size of the available market grows with the adoption of DVB-H handsets over time.

In adoption process, a population member makes an adoption decision and therefore, usually irrevocably, changes state from non-adopter to adopter. This process usually takes the shape of an S-curve showing cumulative diffusion over time, and a bell-shaped curve showing the rate of diffusions per period over time, as shown in Figure 14. The cumulative penetration always increases over time and approaches a saturation level (100% in Figure 14) as an asymptote. (Meade & Islam 2001)

The bell-curve closely resembles the normal distribution. Rogers (2003) has suggested the widely known division of people into five adopter categories based on their time to adopt an innovation and other behaviour characteristics. These five categories and their respective percentage shares are innovators (2.5% of adopters), early adopters (13.5%), early majority (34%), late majority and laggards (16%). Figure 15 below illustrates the division.

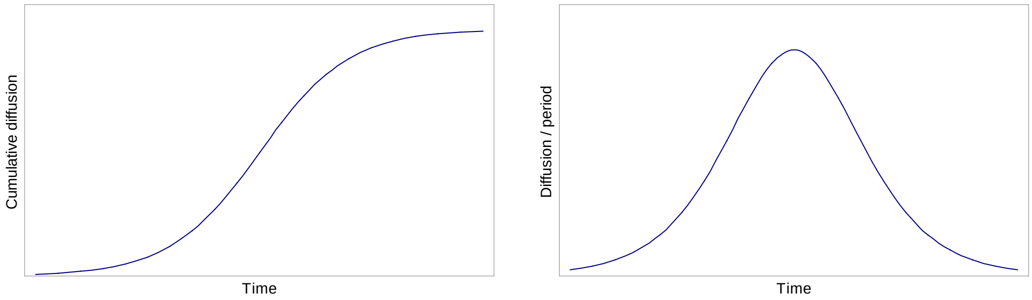

Figure 14: An idealised logistic S-curve and an idealised bell-curve.

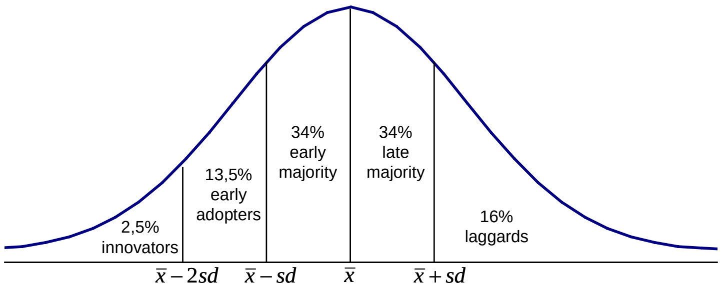

Figure 15: Innovation adopter categories (Rogers 2003).

The reality of technology adoption is complex. Changes in for instance consumer needs and desires, the overall economic development, or competition between different standards and different vendors, can have a great impact on the process. Identifying all significant factors and accurately modelling their effects on the process would be hard or impossible.

Meade and Islam (2001) have compared numerous diffusion models against documented diffusions of actual innovations. They found out that simple models, such as the logistic curve, tend to produce more accurate forecasts than more complex ones, especially when the forecast is based on historical time series data with few observations.

Logistic and Gompertz functions

For the purposes of this thesis, we choose two simple forecast models: logistic and Gompertz functions. They both generate an S-curve, but the logistic function is symmetric about its point of inflection, whereas the Gompertz function is asymmetric. Figure 16 below illustrates the two curves.

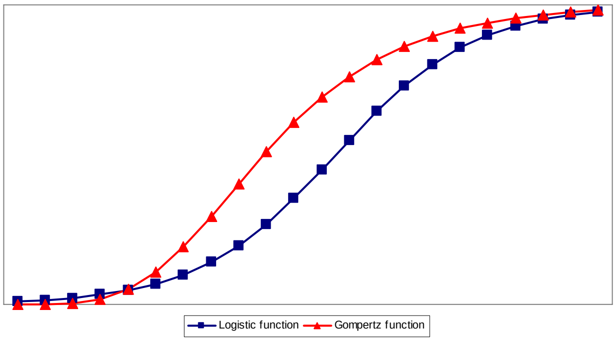

Figure 16: Examples of Logistic and Gompertz functions.

The equation of the logistic function is:

$$f(t) = \frac{a}{1 + ce^{-bt}}$$

The equation of the Gompertz function is:

$$f(t) = ae^{-ce^{-bt}}$$

Where a denotes the saturation level, i.e. the upper asymptote, and b and c are shape parameters.

We can test the shapes of the functions by fitting them against actual data of GSM diffusion in Finland, as shown in Figure 17 below. The data is from Mäkinen and Nokelainen (2003) and Ministry of Transport and Communications (2006b). Clearly, with right parameters, both models can take the shape of mobile phone diffusion process. Note that this test does not measure the functions' ability to forecast the diffusion.

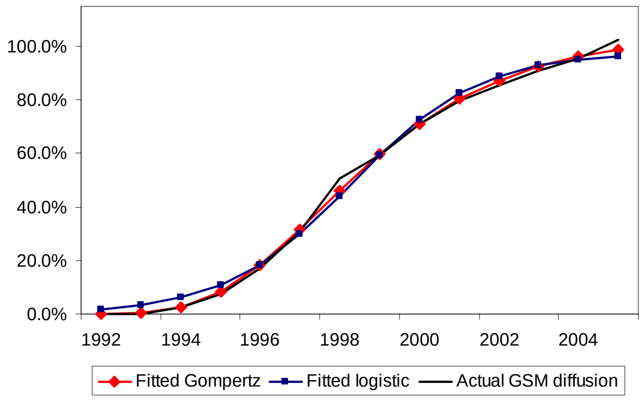

Figure 17: Logistic and Gompertz curves fitted to GSM diffusion in Finland.

Now, using these two functions and some unorthodox amendments, we can form forecasts of the DVB-H handset adoption. We want to create three different adoption forecasts to test the sensitivity of the business case to the number of handsets. We call the three forecasts optimistic, average, and pessimistic cases.

Optimistic forecast: DVB-H catches up smartphones

Many of the interviewed experts predicted that DVB-H capability would eventually be in all handsets. Some predicted that mobile phones would be only one class of devices among many others: car navigators, gamepads, handheld media players, etc.

For the purpose of this thesis, we make a prediction that during the study period the DVB-H capability will be included mainly in the smartphone category. Smartphones are the higher-end mobile phones that run on a commercial operating system, such as Symbian S60 or Windows Mobile, and allow installing additional native applications. Smartphones are a likely platform for the DVB-H capability, because handling a high bit rate video requires a lot of computational power and especially a decent colour screen of at least few inches across.

In Finland, Nokia is the clear market leader in smartphones with almost 99% market share (Kivi 2006, 2007). A possible scenario then is that Nokia, by a vendor decision, includes DVB-H capability in majority of its smartphones in the future. This enables us to estimate the DVB-H handset adoption against the smartphone adoption so that the DVB-H handsets will catch up with the smartphone diffusion curve and then continue growth along it.

Such strategy would help Nokia as a handset manufacturer to promote DVB-H adoption as well as boost the sales of its higher end devices. The scenario is plausible, as Mr. Kallasvuo, the CEO of Nokia, recently publicly estimated the cost of a DVB-H receiver chip and antenna to be together around seven euros in 2008.

To model this scenario, we can fit the Logistic and Gompertz functions to the actual time series data we have for smartphone adoption in Finland. We do this by using the least squares method.

Least squares method attempts to find a function that best approximates a given set of data points. It does this by minimising the sum of the squares of the ordinate differences, i.e. residuals, between the points generated by the function and the corresponding data points. The sum of the squares of the residuals (S) is given by the equation:

$$S = \sum_{i=1}^{n} (y_i - f(t_i))^2$$

Where:

n = number of data points

t_i = point of time in years

y_i = data point at t_i

$f(t_i)$ = point generated by the function at t_i

We then solve for the parameters *a*, *b* and *c*, so that the sum of least squares between the functions and actual data is minimised. Table 17 below shows the results. The historical smartphone data is adapted from Ministry of Transport and Communications (2006b). Data point for 2006 is our own estimate based on live network measurements from late 2005 and 2006 (Kivi 2006, 2007).

Table 17: Forecast functions fitted to smartphone data.

Parameters	**Logistic**	**Gompertz**
a	56%	100%
b	0,695	0,218
c	114,959	6,302
Actual data points	**Function generated points**	
y_1 (2001) = 0.0%	0,48%	0,18%
y_2 (2002) = 1.2%	0,95%	0,63%
y_3 (2003) = 2.4%	1,88%	1,69%
y_4 (2004) = 3.7%	3,64%	3,76%
y_5 (2005) = 6.1%	6,84%	7,15%
y_6 (2006) = 12.5%	12,20%	11,98%
Least squares (*S*)	0,00011	0,00021

The least squares value (*S*) of the logistic function is better than that of the Gompertz function, indicating a better fit. The logistic function forecasts that the smartphone penetration will reach 56% penetration (after 2013) whereas Gompertz function forecasts 100% penetration (much later). Figure 18 below shows the functions fitted to the smartphone data.

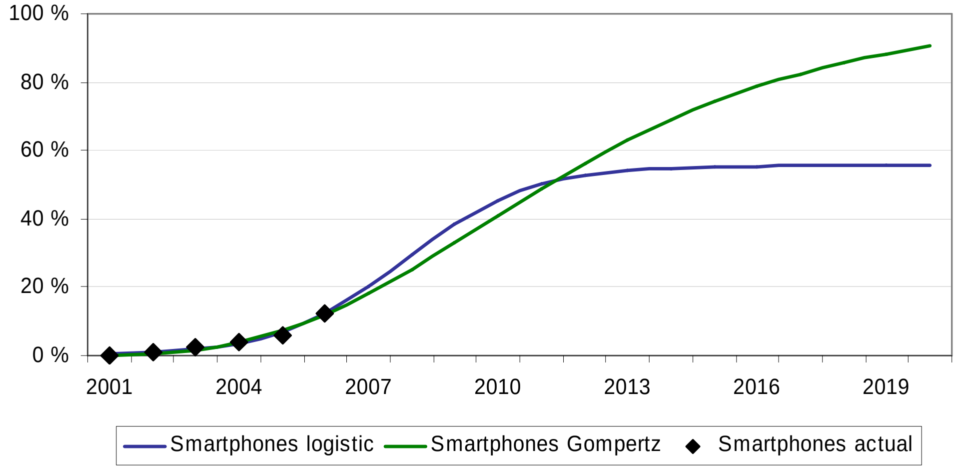

Figure 18: Smartphone adoption forecasts, logistic vs. Gompertz.

The next step is to make DVB-H handset penetration catch up with the smartphone penetration. As discussed earlier, we expect Nokia to include the DVB-H capability eventually in all of its smartphones.

First DVB-H enabled handsets were introduced in 2004 for pilot network testing purposes. Commercially available handsets from Samsung and LG appeared in mid-2006 together with the first commercial network in Italy. In Finland, the first handsets are expected to be the Nokia N92 and N77 smartphones, possibly available during 2007.

DVB-H capability is a handset feature, so we can estimate its adoption using some previously introduced features. Ministry of Transport and Communications (2006b) has published time series data from 2001 to 2005 for the so called 'feature phones' and phones with built-in camera.

The term feature phone is defined as a handset having at least the following features or abilities while not being a smartphone: colour screen, GPRS, WAP, MMS, and Java.

We can shift the 2001 - 2005 data points of built-in camera and feature phones forward in time, so that the curves begin in year 2007. Figure 19 below shows the result. The feature phone has diffused much faster than the built-in camera.

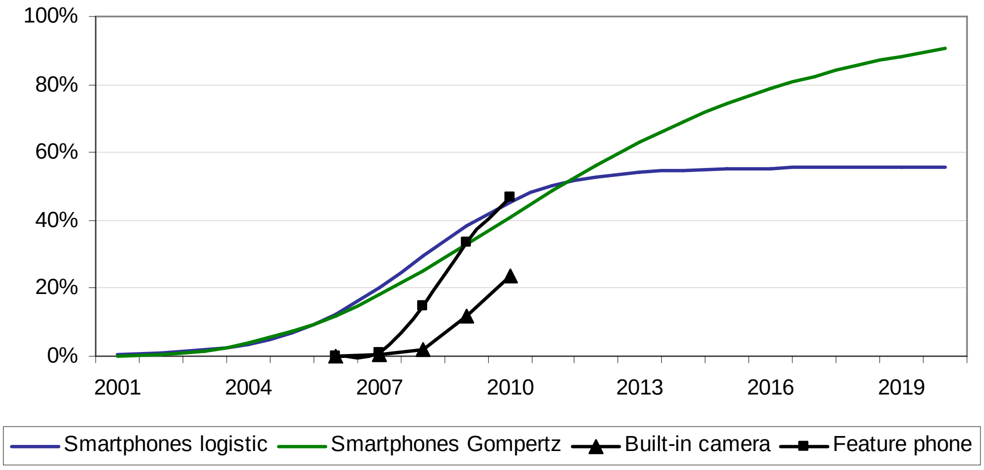

Figure 19: Previous phone features' adoption curves shifted forward in time.

By extrapolating these shapes to catch up with the logistic and Gompertz functions, we get forecasts based on historical feature adoption data.

We choose the logistic function as a basis for the optimistic scenario because of its better fit and more credible forecast for eventual penetration, although, the function values during the study period, from 2007 to 2011, are quite similar. From the two feature curves, we choose the built-in camera, since its curve is less vertical and since it resembles DVB-H in the sense that, when it was introduced, it required a better screen and more memory from the mobile phone, and sold at a significantly higher price.

We then build the optimistic scenario so that we let the DVB-H diffusion start with same curve as built-in camera did, and then extrapolate the curve to catch up with smartphone diffusion forecast based on logistic model. The optimistic scenario forecasts 50% penetration at the end of 2011.

Average and pessimistic forecasts

To get the average and pessimistic scenario we do not use any actual data. Instead, we choose applicable parameters by hand for two Gompertz functions, so that the resulting curves represent downscaled versions of the optimistic forecast. The average and pessimistic functions are pure Gompertz functions, whereas the optimistic forecast is a mixture of a logistic function and actual diffusion data of built-in camera. Figure 20 below shows the resulting different DVB-H diffusion scenarios side by side.

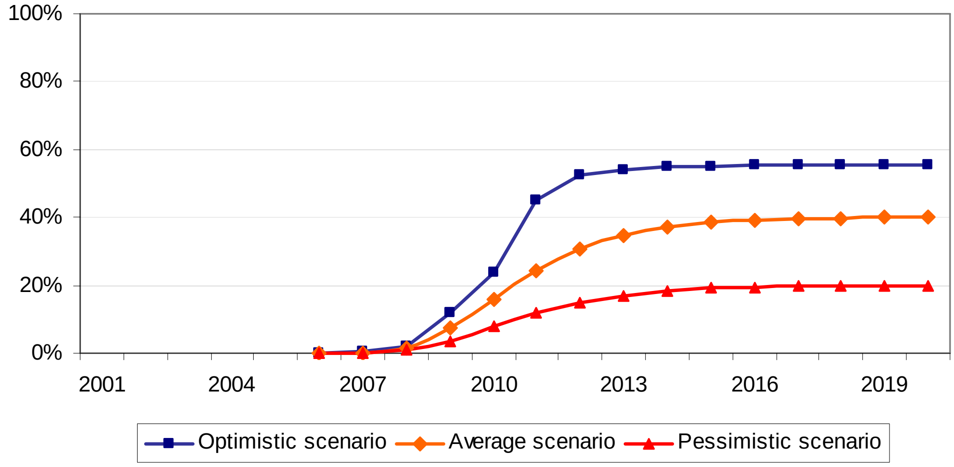

Figure 20: Handset adoption forecasts.

The average scenario forecasts around 24% penetration at the end of 2011. The figure for the pessimistic scenario is 12%. We can think of the normal scenario as the result of the mobile TV being left in a kind of multimedia handset category. Similarly, we can think of the pessimistic scenario as the result of mobile TV staying a niche feature or, alternatively, as the lack of demand resulting from poor pricing, low quality content, or strongly weakening socio-economic conditions.

3.6.4 Service demand

Now that we have estimates for the DVB-H handset adoption, we can construct a model of the market demand for channel packages. As Carlsson and Walden (2007) write, the drivers for the demand for mobile TV so far are close to unknown – apart from the idea that most people would likely prefer flat, understandable pricing and good content.

In the calculation model, we handle the demand for channel packages separately from other TV services and interactive services. We apply a simple differential pricing approach for the channel packages, and set a rough market penetration estimate and average consumer spending per year (ARPU) for all other services.

Initial demand data

Although forecasting the market demand for a mobile service such as mobile TV is predominantly about guessing, we can resort to some recent consumer data gathered in various studies.

Mäki (2005) reports the results of a survey conducted during the Finnish mobile TV pilot in 2005. The sample consisted of 486 persons living in the capital region. They were given a DVB-H enabled handset and were shown mainly simulcasts of regular DVB-T channels against a monthly flat rate of EUR 4.90. According to the survey results:

- Around 40% of participants said that they would be ready to pay EUR 10 per month.
- Around 1% of participants said that they would subscribe to the services as soon as they are available, and further 14% said that they would subscribe when acquiring their next new mobile phone. These people typically owned a smartphone or a phone with built-in camera.
- Around 26% of participants said that they would subscribe when services would be more common.
- Overall, a fixed monthly fee would be preferred.

Verkasalo (2007) reports the results of a smartphone usage study conducted in Finland during fall 2006. The study combines actual usage data recorded by a piece of software installed on participants' smartphones, related user surveys, and network measurements. The sample size in the study was 695 Nokia smartphone users, and average duration of participation was 68 days. The results include the following observations:

- Around 13% of all smartphone users in the sample at least tried multimedia streaming over WCDMA or GPRS. The percentage was from 19% to 32% for people who considered themselves as experienced smartphone users.
- Around 3% of smartphone users in the sample used or tried WCDMA streaming mobile TV service.
- Around 70% of sample had purchased content using a mobile phone. Around 32% had purchased goods or services.
- Finland lags behind Western Europe and USA in mobile video usage.

Carlsson and Walden (2007) conducted two surveys about the attitudes of Finnish consumers towards mobile TV during 2005. Their samples consisted of 600 randomly picked consumers from around Finland and of 160 participants of the Finnish mobile TV pilot:

- Around 15% of people in the random group indicated interest to try mobile TV in the future (compared to 59% in an 8-country study by Siemens, and 90% in a study about Korea).
- Around 29% of people in the pilot group developed a daily routine of watching mobile TV.
- Around 17% of people in the pilot group had a positive attitude toward mobile TV. Around 29% had a neutral attitude, and around 44% had a negative attitude.

The results of these user surveys are opinions of a certain sample rather than actual buying decisions. Moreover, single measurements of recently launched video streaming services do not indicate which way the market is developing.

Information goods and differential pricing

Shapiro and Varian (1999) define information as something that can be digitised, i.e., expressed in a stream of bits. An information good is a type of commodity whose market value derives from the information it contains. Typical examples of information goods are a CD containing pieces of music, and a newspaper. In this thesis, we then consider mobile TV programmes, channels, and channel packages as information goods.

According to Varian (1997), a well-known feature of an information good is that it has large fixed cost of production, and small variable cost of reproduction. It therefore makes little sense to price information goods based on costs. Rather, information goods should be priced based on consumer value. Since consumers can have radically different values for a particular information good, value based pricing naturally leads to differential pricing, i.e., price discrimination. The purpose of differential pricing, from the perspective of the seller of the information good, is to maximise revenues by extracting as much value from the market as possible.

In this thesis, we apply a differential pricing approach called versioning, also known as vertical differentiation and second-degree price discrimination. This approach refers to a situation in which a seller provides different qualities/versions of a good, which sell at different prices. The seller cannot set the price for the product according to any exogenous observable characteristic such as affiliation with some group, but can set the price based on an endogenous characteristic such as the quality of the version the consumer purchases. (Varian 1997)

The seller wants to price the versions so that the consumers with high willingness to pay (WTP) choose a high quality version at a higher price, and consumers with low WTP choose a lower quality version at a lower price. Versioning thus enables the process of customer self-selection, in which customers sort themselves into different groups (segments) according to their WTP. (Varian 1997)

Channel bundling

Shapiro and Varian (1999) define bundling as a special form of price discrimination in which two or more distinct products, which are also available separately, are offered as a package at a single price. If the products cannot be bought separately, the conduct is called tying.

Literature suggests that bundling of information goods can be valuable as it reduces the dispersion in the consumers' WTP. This means that the consumers' valuation for a bundle of goods typically has a probability distribution with a lower variance per good compared to the valuations for the individual goods. Such reduction in buyer diversity typically helps sellers extract higher profits from all consumers. (Shapiro and Varian 1999, Bakos and Brynjolfsson 1999)

According to Bakos and Brynjolfsson (1999), the larger the number of goods bundled, the greater the typical reduction in the variance of consumers' valuation, as Figure 21 below shows. Their model assumes linear demand and independent and identically distributed consumer valuations.

Figure 21: Demand for bundles of information goods (Bakos and Brynjolfsson 1999).

Moreover, practically all of the experts we interviewed said that the mobile TV channels ought to be sold in channel bundles, i.e., channel packages, as it would be easier and perhaps more cost effective than selling single channels. Moreover, bundling a channel subscription together with a DVB-H handset and a mobile subscription was seen as a good way to advance DVB-H.

Rautio, Anttila, and Tuominen (2007) have studied bundling of information goods in Finland. Their results do not support anticipated advantages of bundling very strongly, but bundling did reduce the dispersion in customer valuations and increased demand of information goods slightly. Another finding is that consumers in Finland strongly prefer flat rate pricing.

Therefore, we build the model so that broadcast service operators offer channel packages at flat monthly rates, and the number of channel packages ranges from one to three, depending on the capability of the operator. Varian (1997) suggests that in the absence of additional information, having three versions rather than one or two may be attractive due to “extremeness aversion” on the part of consumers. This means that when presented with three different versions of a good, e.g. a microwave oven, a consumer often chooses the middle-priced one.

We name the three possible channel packages as, from cheapest to most expensive, bronze, silver, and gold. The number of channels in a channel package is limited by the rule of maximum 1/3 of total capacity per player and the maximum channel capacity of the network. The price of a channel package correlates positively with the number of channels in the package. The subscribers then naturally sort themselves into bronze, silver, and gold segments based on their willingness to pay and package choice.

Feature based demand model for channel packages

We apply Varian (1997) and Dedeke (2002) to derive a demand function for channel packages. In the model, a service operator employs versioning, or quality based price differentiation, so that more channels in a package means more quality and a higher price. The word quality here refers to the features or capability of the package, namely the number of channels, but also to the quality of the content.

We build the offering in the model so that the cheapest package, bronze, has *x* channels. The middle-price silver package has *x* + *y* channels, and the high-price gold package has *x* + *y* + *z* channels. Thus, when a consumer subscribes to the silver package, she actually buys the bronze package plus the additional silver channels. The gold package then, if offered, always has the most and bronze package the least channels.

We then assume that at each price, the demand for silver package is larger than for bronze package, since silver package has the same channels as bronze plus the additional channels. Therefore, if both bronze and silver would cost EUR 10, every rational consumer would choose silver. We thus further assume a certain level of rationality to be present among consumers in the calculation model.

For simplicity, we assume that the demand curves for the channel packages are linear. Figure 22 below illustrates the demand model. The curves are not to scale in this illustration.

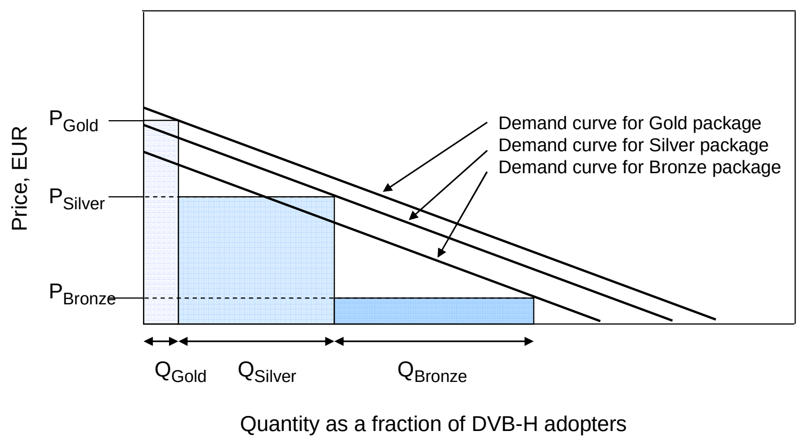

Figure 22: Examples of demand curves for channel packages, not to scale.

We approximate the demand curve of a channel package using and equation producing a linear demand curve:

$$q(a,b,p,c,d) = (a - b*p) - c - d$$

Where:

q = quantity as a fraction of DVB-H adopters.

a = point where the curve intersects the horizontal axis when $c = 0$ and $d = 0$.

b = slope of the curve.

p = monthly subscription price of channel package.

c = effect of the most important simulcasts being free.

d = adjustment for effects of marketing.

One piece of market information we can use to shape the curve is that according to the Helsinki pilot survey, around 40% the participants said they would pay EUR 10 per month for the service. The offered service in the pilot was a channel package that included simulcasts and some extra channels. We can regard the pilot survey's result as the absolute maximum demand for a base channel package, as we consider the pilot users as a biased group and as a price stated as appropriate in a survey can prove much too high in real world situations. Then, by locking the point (q, p) = (40%, EUR 10), and by specifying an appropriate range for parameter a, we get maximum demand levels.

We assume that if the most popular commercial free-TV simulcasts (MTV3, Nelonen, and SubTV according to Statistics Finland 2006b) were included in a pay-TV package, the demand for the pay-TV package would be higher than in the case that these simulcasts were free for consumers. This effect is denoted by parameter c. We also assume that, to some extent, marketing efforts can affect the demand positively. We approximate the effect of marketing efforts so that the higher the marketing spending, the more the curve moves to right. This effect is denoted by parameter d.

Figure 23 below shows a curtain of curves, which act as the upper limit for market demand of the bronze channel package (left side), and a curtain of all possible demand curves we create with the demand model by specifying suitable parameter ranges (right side).

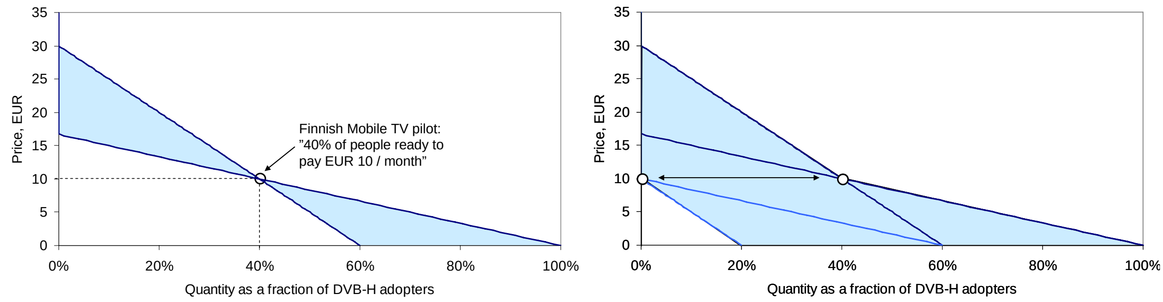

Figure 23: Construction of demand curves.

The resulting range of possible demand curves is wide, and by combining this range with the three handset adoption forecasts, we get an abundant number of possibilities for the popularity of mobile TV channel packages among consumers. We treat the set of possible curves neutrally and set the parameter ranges, which determine the demand function, as uniformly distributed.

We form the silver and gold package demand by scaling parameter *a* in the bronze package's demand curve so that if silver package exists and has more channels than bronze, its curve is always higher. Similarly, gold curve is always above silver curve. We correlate the increase in parameter *a* with the number of extra channels, so that the more extra channels, the greater the increase.

Channel package pricing

Now that we have modelled the market demand for channel packages, we can model a matching pricing plan for a service operator so that a service operator sets a target penetration and a minimum price for each channel package it sells. The operator then in effect segments its DVB-H enabled customers into from one to three segments (based on the number of packages offered) and into non-buyers. This approach is not intelligent in the sense that it does not optimise the results for profit maximisation or loss minimisation.

Table 18 below shows the number of channel packages offered in each different operating model when simulcasts are free and when they are not free for the consumers. The numbers are based on our estimates of the capability of the operator types.

Table 18: Number of pay-TV channel packages offered by service operator.

Operating model	Number of channel packages. Simulcasts are free / are not free.
1. MNO approach	2 / 2
2. MVNO approach	1 / 2
3. Broadcaster approach with outsourced billing	2 / 2
4. Broadcaster approach with in-house pay-TV billing	2 / 2
5. Pay-TV broadcaster with outsourced billing	2 / 2
6. Co-operation approach, MNO with broadcasters	3 / 3
7. Co-operation approach, MVNO with broadcasters	3 / 3

The target penetration depends on the steepness of the demand curve so that the steeper the demand curve, the lower the target penetration. Table 19 below shows the target penetration ranges we estimate for the different channel packages.

Table 19: Target penetration ranges for channel packages.

Channel package	Target penetrations	
	If simulcasts are free	If simulcasts are not free
Bronze	30% - 50%	60% - 80%
Silver	10% - 18%	16% - 25%
Gold	3% - 6%	6% - 8%

The calculation model then reads a price that corresponds to the target penetration on the demand curve. If the indicated price is lower than the minimum price, the calculation model uses the minimum price instead. The minimum price for the bronze channel package is set to range from EUR 3 to EUR 5, and for silver and gold packages from EUR 3 to EUR 5 and from EUR 2 to EUR 4 respectively. The minimum prices correlate with the number of channels so that the more channels there are in a package, the higher the minimum price in general.

Note that the actual percentage of people subscribing to bronze channel package is calculated as bronze penetration minus silver penetration minus gold penetration, and so forth. Figure 22 on page 77 shows an example of this so that the segment Q_{Bronze} in the figure indicates the actual penetration.

Channel package revenues

We need three further considerations to calculate the channel package revenues: the service operator’s market share of all DVB-H adopters, the average number of months people subscribe to the channel packages per year, and the dealing with customers with bundled handsets.

We set the service operator market share to 30% for a vertically integrated mobile operator, to 10% for an MVNO, and to 50% for a broadcaster type of service operator. The interpretation of the market share is slightly different for mobile operators and broadcasters, making the operating models non-comparable: a mobile operator will sell services only to its own mobile subscribers, but a broadcaster can sell its services through many mobile operators. E.g., MVNO then reaches a maximum of 10% of all DVB-H handset adopters assuming that they are uniformly distributed to all mobile operators. A broadcaster with 50% market share serves 50% of all DVB-H handset adopters through its sales channel partners.

We set the average number of months people subscribe to the channel packages per year to range from 6 to 12 months. For simplicity, we assume that the unit length of a subscription is one month. If a consumer chooses to buy a one-month subscription of a channel package, there is no guarantee that she or he would buy it the next month. Moreover, people might choose not to renew their subscriptions during e.g. holiday seasons.

We model the customers with bundled handsets so that they always get a channel package along with the handset. To determine the channel package choice for bundled customers we use the division of channel packages among the normal customers. Note that also the bundled customers can choose not to continue their mobile TV subscriptions each month, i.e., they do not have to subscribe to the services for 12 months per year.

We can then finally calculate the annual channel package revenue using the equation:

$$R_i = P * E^{(i-t)} * Q * N_i * M * T$$

Where:

R_i = revenue in year *i*.

P = monthly price excluding VAT 22%.

E = channel package annual price erosion.

t = channel package launch year.

Q = share of DVB-H handset adopters subscribing to the channel package.

N_i = number of DVB-H adopters in year *i*.

M = service operator's market share.

T = average number of months subscribed per year.

The price erosion factor ranges from 98% to 100%, i.e., the annual price erosion is at maximum 2%. The service operator can also impose a connection tariff for new customers. Each new customer must pay the tariff once when she or he subscribes to any channel package for the first time. We set the connection tariff to range from EUR 0 to EUR 10, with the exception that customers with bundled handsets do not have to pay a connection tariff.

In addition, we must consider the channel package launch years. The calculation model assumes that bronze channel package exists from the beginning of study period, but silver and gold channel packages can be launched between 2007 and 2009. We approximate the launch date to be on average in the middle of the launch year. Therefore, we calculate the costs and revenues for silver and gold channel packages only for the second half of the launch year.

Demand and revenues for other services

We model the demand for other services more straightforwardly. For each service, we multiply two parameters: the market penetration and the annual average revenue per user (ARPU). Table 20 below lists the parameter values we use in the calculation model.

Table 20: Market penetration and spending parameters for other services.

Service	Market penetration	Annual ARPU, EUR
Pay-TV subscription	5%...30% of DVB-H handset owners	2…10
Pay-TV Pay-per-View	5%...30% of DVB-H handset owners	2…10
3G Streaming VoD	5%...20% of channel package subscribers	2…10
Interactive: Communications	10%...30% of channel pack subscribers	2…10
Interactive: Premium SMS	3%...20% of channel package subscribers	2…10
Interactive: personalisation	3%...20% of channel package subscribers	1…10
Interactive: E-commerce	1%...5% of channel package subscribers	2…10
Interactive: applications and filecasting	1%...5% of channel package subscribers	1…5

3.7 Chapter summary

In this chapter, we have discussed elements we have to consider in constructing the ECOSYS calculation model, from the business ecosystem emerging around DVB-H mobile TV in Finland to the regulative, technology, service, and environmental scenarios.

In the regulative scenario, we have discussed laws and licences regulating DVB-H broadcast network operation, service operation, mobile network operation, and broadcasting in Finland to the degree that they affect the ecosystem and the calculation model.

In the technology scenario, we have presented the DVB-H network structure and the required service system elements for delivering DVB-H mobile TV services. We have also discussed the technical service capability of the DVB-H network in Finland.

In the service scenario, we have presented the different services we consider in the calculation model, as well as a set of different operating models for service operators we derive from the business ecosystem.

In the environmental scenario, we have presented a rough DVB-H network dimensioning, as well as constructed three handset adoption forecasts and a demand model for DVB-H pay-TV channel packages and other services.

4 Results of techno-economic analysis

In this chapter, we present the results of the techno-economic analysis of DVB-H mobile TV operating models. We calculate the results for each of the seven operating models with two options for simulcasts (free or not free for end users) and three different handset adoption forecasts (optimistic, average, and pessimistic). The total number of calculation cases is then 7 * 2 * 3 = 42. Table 21 below shows the different configurations.

Table 21: Configurations of different calculation cases.

Operating model	Simulcasts for consumers	Handset adoption forecast model
1. MNO approach	- Free - Not free	- Optimistic - Average - Pessimistic
2. MVNO approach	- Free - Not free	- Optimistic - Average - Pessimistic
3. Broadcaster approach with outsourced billing (indirect)	- Free - Not free	- Optimistic - Average - Pessimistic
4. Broadcaster approach with in-house pay-TV billing (direct)	- Free - Not free	- Optimistic - Average - Pessimistic
5. Pay-TV broadcaster with outsourced billing	- Free - Not free	- Optimistic - Average - Pessimistic
6. Co-operation approach, MNO with broadcasters	- Free - Not free	- Optimistic - Average - Pessimistic
7. Co-operation approach, MVNO with broadcasters	- Free - Not free	- Optimistic - Average - Pessimistic

We perform 1,000 Monte Carlo simulation runs for each of the 42 calculation cases and present the results separately for mobile operator based and broadcaster based operating models, since the cases are not entirely comparable.

The mobile operator based operating models are the MNO and MVNO approaches and the two co-operation approaches, i.e., models 1, 2, 6, and 7. The broadcaster based operating models are the direct and indirect broadcaster approaches and the pay-TV broadcaster approach, i.e., models 3, 4, and 5. All models have the same discount rate of 8% despite the possibly varying level of risk between the models, which calls for considering also the risks included in different operating models when interpreting the results.

The calculation model does not optimise the results for profit maximisation or loss minimisation. In other words, the model cannot e.g. adjust the number of channels or pricing according to market demand, or discontinue the services even when the project looks incurably unprofitable. On the contrary, the calculation model runs a service operator through the 5-year study period with 1,000 different combinations of simulated market demand, service offering, pricing, and operating costs, and returns the average, best, and worst outcomes along with other statistical data.

Therefore, more important than the numeric values of single cases or operating models is the overall ranking of the operating models against each other according to their economic performance prospects. The ranking, based on comparing the expected NPV results, deviation, and extremes, reveals which operating models have the best performance in a variety of conditions.

4.1 Mobile operator as service operator

Figure 24 and Figure 25 below show the NPV results for mobile operator (MNO or MVNO) based operating models. We arrange the different operating models in accordance to their overall performance in descending order.

The blue bars represent the mean NPV of the business case. There are three blue bars for each operating model, portraying the three different handset adoption cases: optimistic, average, and pessimistic. The associated error bars represent the extremes of NPV, i.e., the best and worst outcomes. Best outcome generally occurs when service demand is high, service pricing is closest to optimal, and operating costs are low. Worst outcome naturally occurs in the opposite conditions. Numeric NPV results and density distributions are included as appendix A and B respectively.

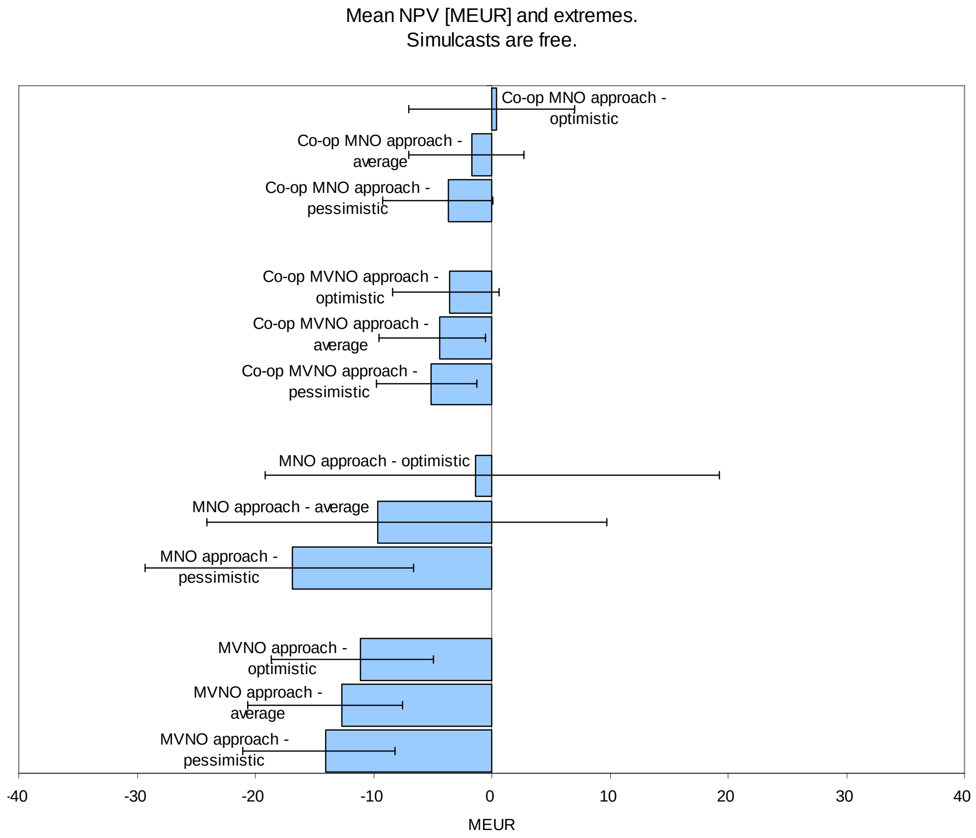

Figure 24: Results for mobile operator and co-op. approaches when simulcasts are free.

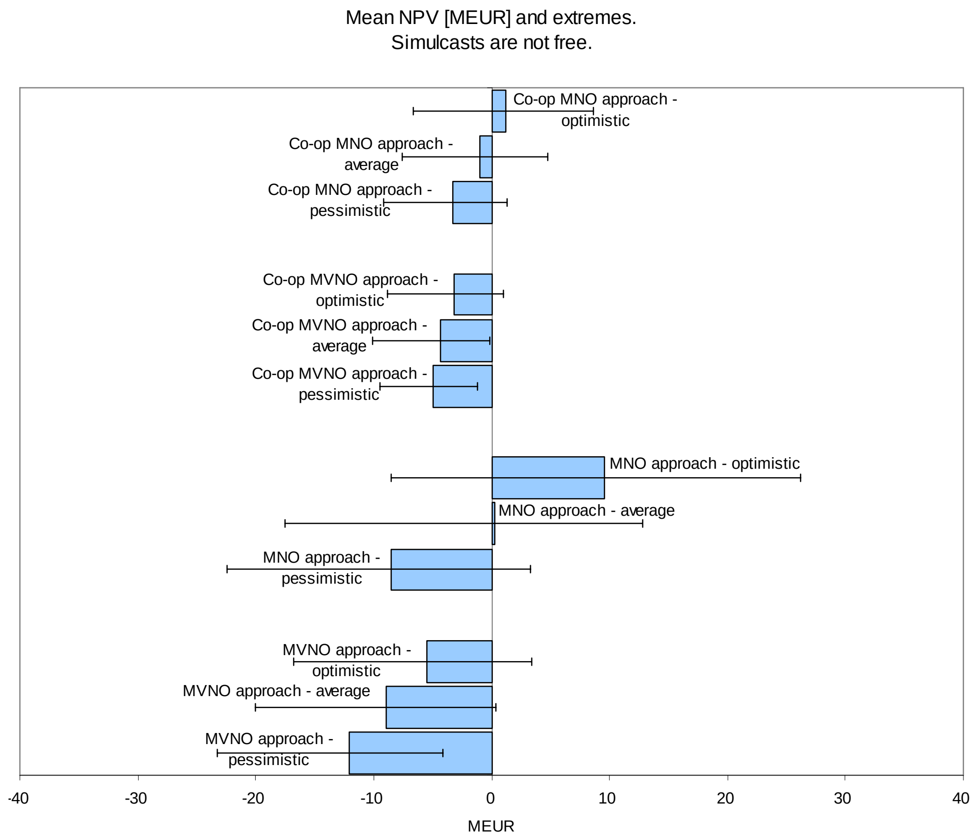

Figure 25: Results for mobile operator and co-op. approaches when simulcasts are not free.

We can see that the co-operation approach is easiest-to-implement for a mobile operator, since it takes care of only sales and marketing, leaving broadcasters to bear the major risks, i.e., capacity and programming. However, the upside potential of the co-operation model is consequently limited. The co-operation model seems to be only slightly affected by the simulcast being free or not free to consumers.

The largest potential for creating value seems to be in the MNO approach. This model however involves buying DVB-H capacity for the services and is therefore much more risky than the co-operation model, causing a wide spread of results. The results also vary considerably between different handset forecasts from optimistic to pessimistic, implying a large dependence on the number of DVB-H adopters. In addition, the MNO approach seems to be greatly affected by the simulcasts being free or not free to consumers. Being able to bundle simulcasts and pay-TV channels together into a channel package can then be a potential value driver for mobile operators.

For a MVNO the business case seems worse. The small market share (10%) means that acting as a broadcaster and buying capacity would likely destroy value, although there is a slight chance of positive NPV when simulcasts are not free and handset adoption forecast is optimistic.

In these mobile operator based approaches, average revenue per user (ARPU) for channel package subscribers ranges from around EUR 2 to EUR 12 per month for the five-year study period. ARPU for all DVB-H enabled customers ranges from EUR 1 to EUR 8. The lower ends of the ARPU ranges occur when average subscription length is at its lowest (6 months per year).

Note that a mobile network operator can also get network infrastructure leasing revenues, which are not included in the above numbers, as they might not be purely incremental cash flows. The infrastructure leasing in the calculation model does not correlate with handset adoption forecasts, and affects only the mobile network operators, not MVNOs or broadcasters. The NPV of infrastructure leasing for the five-year period ranges from MEUR 1 to MEUR 2.

4.2 Broadcaster as service operator

Figure 26 and Figure 27 below show the NPV results for broadcaster based operating models. We arrange the different operating models in accordance to their overall performance in descending order, the blue bars representing the mean NPV of the business case and the associated error bars representing the extremes.

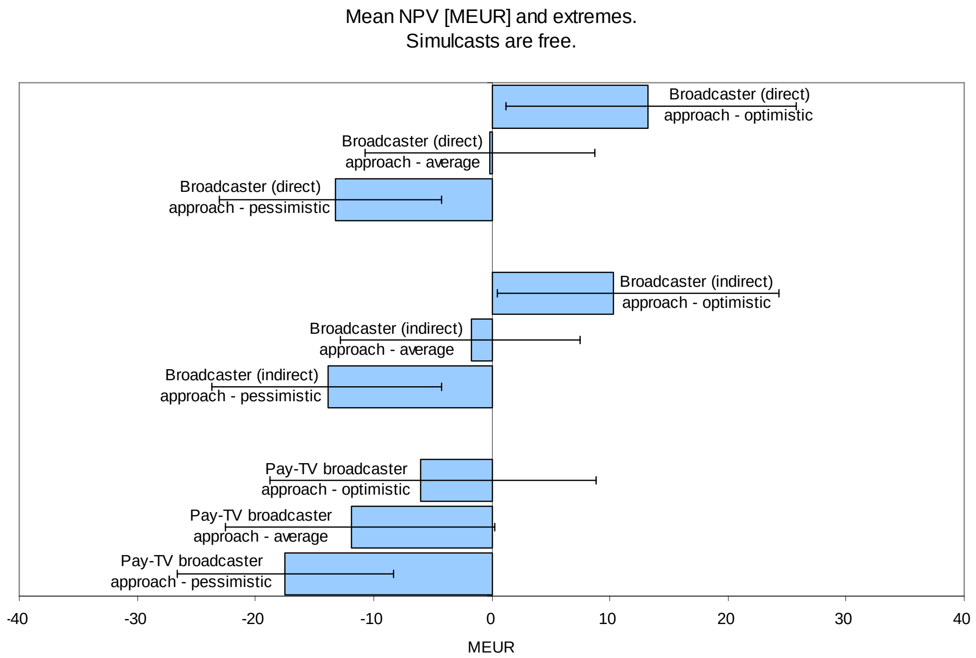

Figure 26: Results for broadcaster approaches when simulcasts are free.

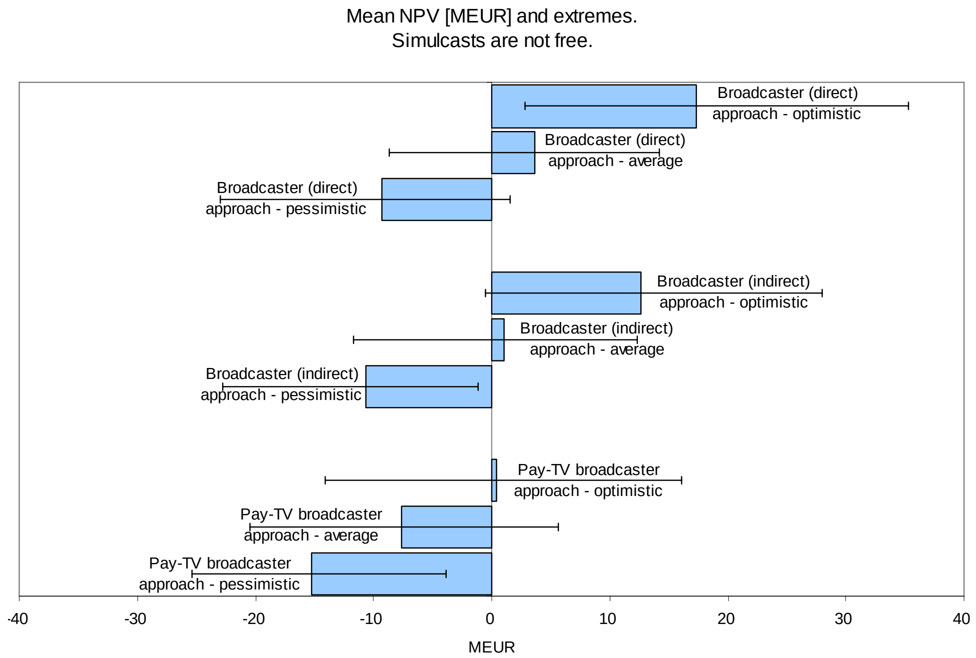

Figure 27: Results for broadcaster approaches when simulcasts are not free.

The results for broadcaster approaches in general have considerably wide spreads, implying that there is a high risk associated with buying DVB-H capacity and programming for the channel packages. The differences between handset adoption forecasts and the wide ranges between best and worst outcomes indicate that the models are very sensitive to the number of handset adopters and to the market demand for pay-TV channel packages.

The simulcasts being free or not free seems to have a notable influence on broadcaster approaches, however smaller than on the MNO approach that we discussed earlier. The reason for this might be in broadcasters being able to get advertising revenues with free-TV channels. Moreover, one broadcaster might not be able or willing to sell the simulcasts of other, competing broadcasters in its packages.

The direct broadcaster approach seems to do slightly better than the indirect, especially when simulcasts are free. This is because billing through mobile operator can be much more expensive than through other sales channels, e.g. a credit card transaction over the Internet. This indicates a possible conflict of interest between mobile operators and broadcasters. Yet bypassing mobile operators in such manner may prove difficult in reality.

This result is in line with the findings of Braet et al. (2006), who write that revenue sharing schemes might turn out to be suboptimal for content aggregators, which neither own spectrum nor have direct customer ownership, as other parties can divide lion’s share of the revenues.

The pay-TV broadcaster approach, in which billing always goes through mobile operator, seems the most difficult, especially when simulcasts are free. The market demand might not support buying large amounts of capacity for pay-TV channels. Moreover, if simulcasts are not free, mobile operators selling the pay-TV broadcaster‘s content can bundle the pay-TV channel packages with some simulcasts making the sales easier.

In these broadcaster based approaches, average revenue per user (ARPU) for channel package subscribers ranges from around EUR 3 to EUR 12 per month for the five-year study period. ARPU for all DVB-H handset adopters ranges from EUR 1 to EUR 5. The lower ends of the ARPU ranges occur when average subscription length is at its lowest (6 months per year). Note that these ARPU’s do not include advertising revenue.

4.3 Sensitivity analysis

We already know from the results that the handset adoption forecast is a major contributor to the distribution of NPV values. To analyse the sensitivity of the calculation model further, we can measure the correlation of different parameters with NPV, i.e., how much NPV changes together with a given parameter.

To assess parameter correlations we use Spearman's rank correlation. To calculate Spearman’s rank correlation coefficient, parameter values and corresponding NPV results are replaced with their rankings from lowest value to highest value using the integers 1 to N (ordinal variables: 1st, 2nd, 3rd, etc.) prior to computing the correlation coefficient. A rank correlation coefficient is in the interval [-1,1], where 1 indicates a perfect agreement between the two compared rankings, -1 indicates a perfect disagreement, and 0 indicates a complete independence. Increasing rank correlation coefficient values between -1 and 1 indicate increasing agreement between the rankings.

To analyse the vast amount of sensitivity data collected in the Monte Carlo simulation runs, we choose to group similar operating model cases together into three groups: mobile operator approaches, broadcaster approaches, and co-operation approaches. The calculated correlations then represent averages over a group instead of a single case. Note that the correlation coefficients may not be completely reliable because certain parameter values are set to correlate with each other already in the calculation model. Therefore, a low-importance parameter that is set to correlate with a high-importance parameter may get a high correlation coefficient. Moreover, taking averages over the groups may cause losing some sensitivity data.

Figure 28, Figure 29, and Figure 30 below represent the top 20 parameter correlations for the different groups in descending order. An asterisk (*) before a parameter name signifies that the same parameter appears in top 20 for two groups, and two asterisks (**) signify that the same parameter appears in top 20 for all three groups.

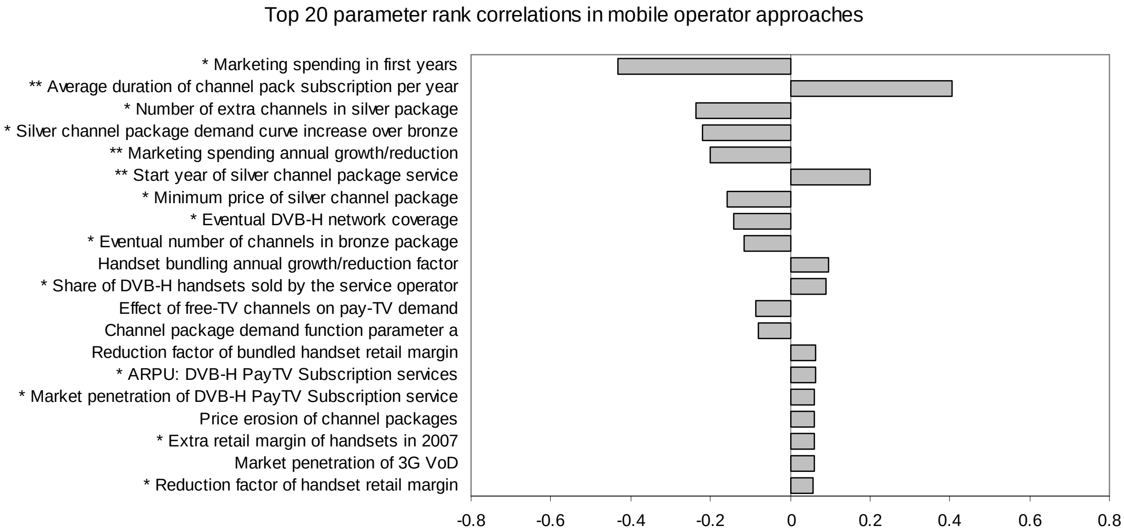

Figure 28: Parameter rank correlation with NPV in mobile operator approaches.

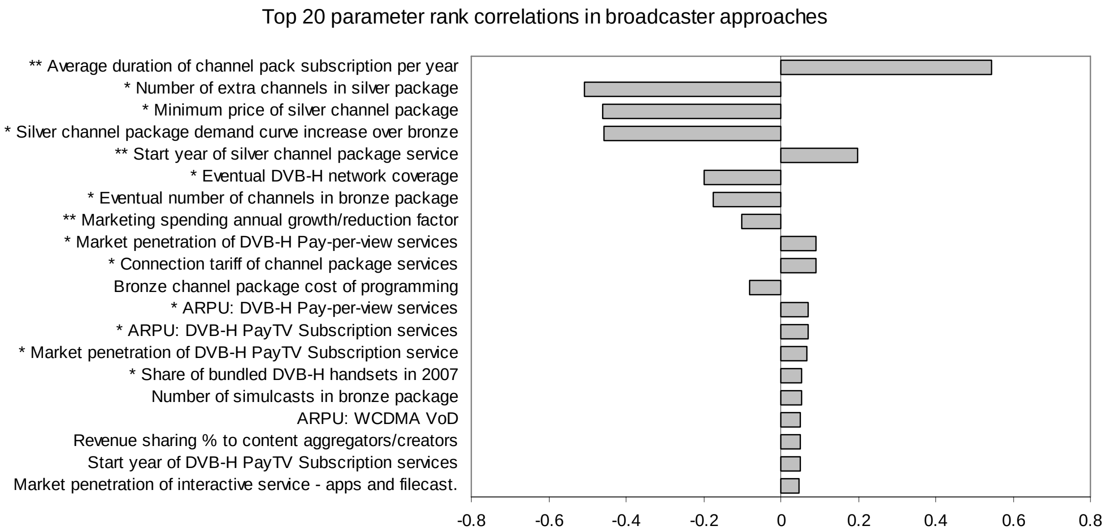

Figure 29: Parameter rank correlation with NPV in broadcaster approaches.

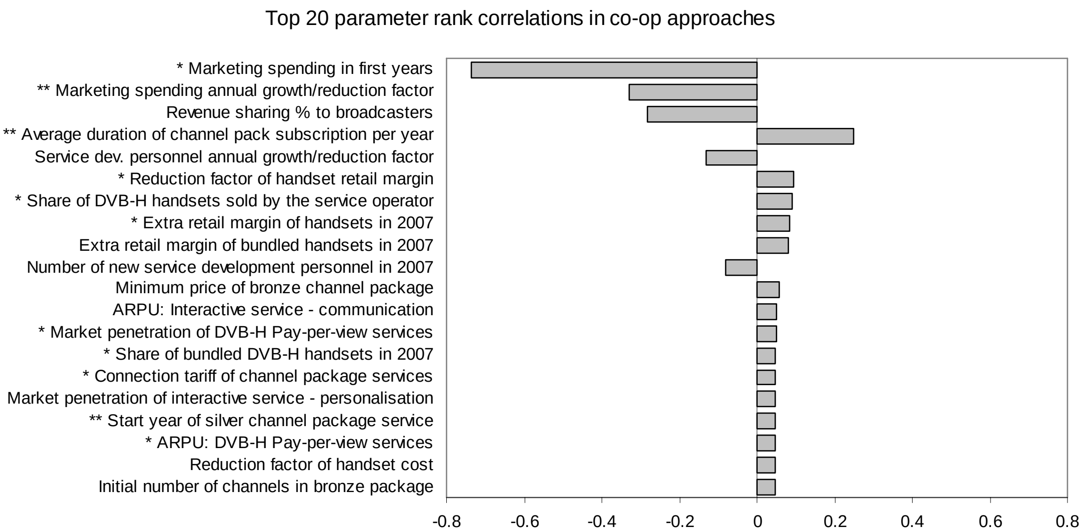

Figure 30: Parameter rank correlation with NPV in co-operation approaches.

Only three parameters appear in all groups' top 20 sensitive parameters: average duration of channel package subscriptions, annual growth/reduction factor of marketing spending, and start year of silver channel package service. The average duration of channel package subscriptions is a central parameter in revenue calculation and has a wide range in proportion to its maximum value: from 6 to 12 months. Marketing spending is also a major cost item in all operating models, and especially in co-operation models, where the mobile operator does not buy DVB-H capacity itself. The start year of silver channel package having a positive rank correlation signifies that it is better to start offering another channel package closer to 2009 than 2007 – the cost of the required extra capacity is too high at low DVB-H handset penetration levels.

Mobile operator approaches and broadcaster approaches seem to be very sensitive to all parameters associated with the silver channel package, perhaps signifying a strong dependence on the pricing of DVB-H capacity and TV programming – many of the parameters are however set to correlate with each other or other parameters already in the calculation model, which can affect the rankings.

The negative correlation of eventual DVB-H network coverage for mobile operator and broadcaster approaches signifies that the associated increase in capacity price might cancel the benefits of increase in potential market size.

It is also notable that the mobile operator models are not very sensitive to handset sales or handset bundling, but increase in DVB-H handset bundling seems to have a positive effect on NPV.

The co-operation approaches differ from the two other groups in that there are no channel capacity related costs, and effect of early marketing spending and its development is significant. The revenue share of the mobile operator is also a sensitive parameter.

Note that advertising revenue is not built with parameters similarly as other revenue generating services and is therefore not included in the above parameter rank correlations.

4.4 Chapter summary

In this chapter, we have covered the results of the techno-economic analysis of DVB-H mobile TV operating models for mobile operators and broadcasters as well as conducted a sensitivity analysis of the results on parameter level.

Overall, the NPV results do not indicate that DVB-H mobile TV would be a tremendous value creation opportunity for mobile operators or broadcasters in Finland during the first five years.

The co-operation approach seems to be least risky and easiest for mobile operators, since broadcasters would bear the DVB-H capacity risk and provide programming, whereas mobile operator would take care of sales and marketing of the services to consumers. The highest upside potential for mobile operators seems to be in MNO approach in which mobile operator would take also the broadcaster's role and buy required DVB-H capacity and programming. This model however is associated with considerably higher risks.

For broadcasters, the best operating model seems to be in selling DVB-H services directly to consumers, bypassing mobile operators (direct broadcaster approach), since mobile operators take a large share of the revenues for billing. This indicates a possible conflict of interest between the two key parties. However, bypassing mobile operators can prove difficult in reality. A broadcaster selling only pay-TV services through mobile operators (pay-TV broadcaster approach) seems to be the most difficult case.

Apart from DVB-H capacity, the most influential factors for the operating models seem to be the DVB-H handset adoption forecast, channel package market demand, and the duration of channel package subscriptions per year. Marketing related costs are also significant.

5 Conclusions

In this chapter, we discuss further the results of the techno-economic analysis of DVB-H operating models, the reliability and validity of the results, and possibilities for exploitation of the results in practice. We also discuss briefly some possible items for future research.

5.1 Results

Overall, it seems that DVB-H mobile TV will not be a tremendous value creation opportunity, let alone the next ‘killer application’, for mobile operators or broadcasters in Finland, at least during the first five years. The results then support the dominant expectations of the interviewed experts.

For mobile operators, the least risky and easiest-to-implement operating model seems to be co-operating with broadcasters to bring the DVB-H services to market. According to the proposed model, broadcasters would buy the required capacity as well as provide the programming, while mobile operators would take care of sales and marketing of the new services to consumers.

The foremost upside potential for both mobile operators and broadcasters would be in performing also the other party’s role, that is, a mobile operator becoming a DVB-H broadcaster (MNO approach) or a broadcaster selling DVB-H services directly to consumers, bypassing mobile operators (direct broadcaster approach). These operating models are, however, associated with considerably higher risks. The results then indicate a possible conflict of interest between the two key parties regarding the sharing of costs and potential revenues.

However, it is unlikely that mobile operators would start buying capacity or that broadcasters could bypass mobile operators in reality. There are economies of scale in broadcasting, and a small mobile operator does not have the scale or the competence to beat broadcasters in the business of offering quality content. Similarly, mobile operators already send a bill each month to their customers and are used to billing only tiny amounts. Building a comparable billing system could prove very time consuming and expensive for broadcasters. Therefore, the co-operation approach would seem the most likely scenario in Finland.

Yet a major issue for the ecosystem in Finland is who pays for the DVB-H capacity. Broadcasters see that they already reach the whole population through conventional TV, and that in the first years DVB-H would not yield any significant advertising revenues. Buying DVB-H capacity would then only deteriorate the current operating margins of the TV channels. It is then likely that broadcasters might want to wait for there to be more handsets in the market first, deepening the ‘chicken and egg’ dilemma.

Note that both broadcasters and mobile operators have already accumulated sunk costs with DVB-H background work, trials, and negotiations during the last 5 years or so. These sunk costs are not included in the analysis and actually should not affect the decisions whether to go ahead or not.

In addition, the horizontal operating model reduces the chances of service differentiation for mobile operators, as is not feasible for a TV channel to be restricted to the customers of only one mobile operator when distribution (capacity) costs are fixed and number of consumers with DVB-H handsets is small. Therefore, operators participating in DVB-H will likely offer the same basic TV channels and some additional pay-TV channels.

5.2 Assessment of results

The primary objectives of this thesis have been to construct a techno-economic model of the DVB-H service business ecosystem and to use it for assessing the feasibility of the business case and for ranking different business models. The secondary objective of this thesis has been to gain more understanding of the related technical, economic, and regulative issues, and to develop further the means of conducting a techno-economic analysis of a service business case. Having provided the needed results and built a high-level view of the business ecosystem and its major technical, economic, and regulative constraints, we can conclude that the thesis more or less achieves both its primary and secondary objectives.

As a part of the research process, we have identified the key roles and interactions in the DVB-H business ecosystem. The calculation model we have built for the analysis is based on these roles and interactions as well as a number of regulative, technical, and economic conditions. Yet the calculation model has to make rough simplifications of reality in many aspects. It for instance assumes linear service demand curves and constant growth or reduction rates for many OPEX elements. Moreover, the calculation model is not intelligent in the sense that it cannot optimise for profit maximisation or loss minimisation.

The calculation model nevertheless produces results that are both logical and in line with the expectations of majority of the interviewed experts. We can therefore say that the ECOSYS methodology has proved applicable for evaluating such service business case and that reproducing the operating model study conducted in this thesis would yield similar results and conclusions.

The results, although being based on a consistent and tested techno-economic approach, are still predictions about the future, and thus by definition uncertain. To improve the validity of the results, we have built the calculation model so that it considers uncertainty already at parameter level and so that it allows testing thousands of combinations of different parameter values to identify sensitivities. The calculation model itself has also been built on a number of assumptions about the structures of cost and revenue elements. Especially some of the operating cost elements are modelled vaguely, and the weight of marketing may be overestimated. These underlying assumptions related to the calculation logic (formulas etc.) constitute possible sources of systematic error in the calculation. Evaluating the magnitude of this systematic error is however difficult, since there is no comparable data available.

For the above reasons, we have been careful in making conclusions about the best operating models for mobile operators and broadcasters, and have used mainly the overall performance rankings rather than any single parameters or NPV figures.

Note that the results of this thesis are based on simulated market conditions representing the Finnish market, and cannot be directly generalised to any other settings or markets.

5.3 Exploitation of results

Parties interested in providing DVB-H mobile TV services have likely conducted their own profitability calculations for internal use. In this thesis, we have provided a public and impartial assessment of the business case from service operator viewpoint, partly based on discussions and interviews with experts from different sides of the ecosystem.

Mobile operators, broadcasters, and other parties interested in DVB-H mobile TV business can use the results for reference and comparison with their own calculations. More importantly, our results can provide avenues for new discussions between the parties.

5.4 Items for future research

This thesis studies the cash flows of DVB-H mobile TV services with a high level of abstraction about the underlying business ecosystem. The study also concentrates on mobile operators and broadcasters as the service operators.

The current calculation model does not optimise the service offering and pricing for profit maximisation. Designing for instance more accurate demand models and an adaptive supply function for a service operator would make the calculation model more 'intelligent' and more realistic. This would refine the outcomes by accepting only healthy combinations. Another improvement could be evaluating the business case using real option approach to see how the operating models would perform if operations were e.g. delayed for some time.

It would be also beneficial to study further the relative powers and capabilities of all players involved in service delivery. This could help in choosing optimal business models, designing the best mobile TV value proposition, and determining the viability of the business ecosystem as a whole.

6 Further discussion and final remarks

In this chapter, we discuss the relationship between streaming mobile TV and broadcast mobile TV as well as the general outlook of DVB-H services in Finland and on a global scale.

6.1 Streaming vs. broadcast mobile TV

Mobile TV services are already available in Finland through WCDMA or GPRS unicast streaming. So why build another network?

The problem with unicast streaming is twofold. First, it does not scale. Current streaming usage is low and there is idle capacity in the mobile data networks, but if more and more users would sign up, network resources would quickly become congested and service quality would degrade.

Second, mobile operator revenue per megabyte in video streaming is very low compared to some simpler services, leading to uneconomical use of expensive wireless capacity. If we consider a person watching 96 kbps streaming mobile TV half an hour per day, the amount of data transferred during a month would be 650 MB – yet the price could be as low as EUR 10, i.e., around EUR 0.015 per MB. This example might be quite an extreme case, but Table 22 below lists typical revenues per megabyte for various mobile services.

Table 22: Revenue per megabyte for different mobile services

Service	Size, MB	Typical revenue, EUR	Revenue / MB, EUR
SMS	0.00014	0.10	714.29
MMS	0.010	0.38	38.00
1 min. voice call	0.141	0.08	0.57
3 min. low quality video stream (120 kbps)	2.7	2.00	0.74
3 min. high quality video stream (384 kbps)	8.6	3.00	0.35
30 min. low quality video stream (120 kbps)	27	5.00	0.19

We can see that in this sense SMS is the crown jewel of mobile services, whereas video services make much less profitable use of the bandwidth. As mobile operators must recover the bandwidth costs from their subscribers, and as the bandwidth is unlikely to become cheaper in the future because of physical constraints, using it to deliver large amounts of video is questionable.

Moreover, a recent survey conducted in five European countries proclaims that ex-users of streaming mobile TV services outnumber current users. The survey of 22,000 mobile subscribers lists pricing, quality, and reliability as the most common issues causing users to switch off the services. (Tellabs 2007)

The rationale behind building DVB-H therefore is that WCDMA or GPRS networks are not optimal for delivering video on the large scale, and a separate broadcast network is needed to enable high-quality TV services for mobile handsets.

However, we find it unlikely that DVB-H would completely replace WCDMA in providing multimedia streaming services, as WCDMA (and GPRS) has the advantage of being already widely deployed and able to provide video on demand (VoD) type of services. Quite the opposite, we expect these two forms of mobile TV to coexist and complement each other at least in the short term.

Then again, from the consumer's point of view, it should be quite irrelevant which technology is being used to deliver the TV shows to the mobile, as long as some required level of quality and ease of use is achieved. Getting both delivery paths under the same charge would probably be easiest for consumers.

6.2 General outlook of DVB-H

In Finland, commercial DVB-H services can be further delayed due to uncompleted negotiations about copyright payments concerning simulcasts. One possible reason for the problem may be that copyright holders were not involved in the designing of the DVB-H services from the beginning. Collecting societies insist that DVB-T related payments do not automatically cover DVB-H transmissions, and broadcasters say that they will not put their channels on DVB-H if they have to pay any extra copyright payments for the same signal that is already available to 100% of the population. As a result, at the time of writing, there is only one TV channel on air and there are no handsets available to the public.

The dominant belief among interviewed experts was that simulcasts are necessary to bring the audiences to mobile TV and to get the handsets sold, but the actual value will be in pay-TV services in the future.

Finland could have acted as an important road opener for DVB-H, but it seems that Italy has already set the reference case, and other markets can soon be zooming past Finland. In Italy, unlike in Finland, which follows the EU ideal of horizontal operation (i.e., decoupling of networks and services), the launch was based on a vertical operating model. Mobile operator Hutchinson 3 Italia operates the DVB-H network, produces some of the offered channels, and sells the services to consumers. The operator reported signing up 111,000 subscribers in the first six weeks of operation (DVB-H Project 2007) and in total 300,000 by 1 January 2007 (Variety 2007) - significantly less than the forecasted 500,000.

Broadcast mobile TV game, however, was opened in Korea already in 2005 with satellite based S-DMB and terrestrial T-DMB technologies. The services have been taken up fairly well; S-DMB was reported having almost 1 million subscribers at the end of 2006, out of total 40 million Korean mobile subscribers (Techworld 2006). Shin (2006) however questions the mobile TV market in Korea saying that its developmental momentum came mainly from an industry eager to come up with a new cash-cow service, and not from the consumers' side.

Significance of DVB-H technology

Resembling S-DMB and T-DMB in Korea, DVB-H mobile TV is a new technology being hyped and eagerly pushed to mobile subscribers by the mobile industry. There have been DVB-H pilots in virtually all major countries in Europe, and Nokia as a handset manufacturer has been very active in the process. Not surprisingly, in 2006 broadcast mobile TV made it to the top of Gartner's (2006) hype cycle, the "peak of inflated expectations" phase before grand "disillusionment".

Presumably, Nokia is attempting to sell more high-end smartphones with mobile TV capability. However, on a larger scale, we can think of DVB-H as an extension to the GSM/WCDMA evolution from Nokia's viewpoint; Nokia could want to replicate the global success of GSM with DVB-H. There can then be much more at stake with DVB-H than just another mobile TV service.

Rivalling broadcast mobile TV technologies, such as MediaFLO and T-DMB, originate from the North-American and Asian markets, where GSM and WCDMA have to compete with other cellular technologies. It may then well be imperative for Nokia that DVB-H would become the dominant standard in Europe, enabling EU-wide service availability. This would continue the GSM camp's dominance in the region, and possibly help advance both technologies on the other continents. Even so, a common belief is that different regions will nevertheless use different technologies, which has so far always been the case with broadcasting, as Shapiro and Varian point out (1999).

The concept of mobile TV itself can also be seen as a small part of a broader evolution of TV. The beginning of TV was about free-to-air analogue broadcasting. The next step was analogue cable TV and satellite TV, which enabled more channels and pay-TV services. The next step was to digitalise TV and to make more efficient use of radio spectrum and enable advanced services. Following the digitalisation, the current phase is about the expansion of TV to the Internet and mobile phones. The evolution then seems to head towards a strong diversification of TV access and a multitude of receivers (Arthur D. Little 2006, Kallioja 2006).

Other considerations

Besides the standard competition coming from USA and Asia, there is technological fragmentation even within the DVB-H camp. Different system vendors push incompatible digital rights management (DRM) implementations and/or electronic service guide (ESG) implementations. Therefore, a phone sold in Finland might not be able to receive DVB-H transmissions in Italy, undermining the prospects of a pan-European mobile TV.

The most significant concerns should however be whether the overall value proposition of mobile TV is sound, and whether there really is consumer demand for mobile TV outside analyst reports and pilot surveys.

Shin (2006) writes that mobile TV services in Korea may have been based primarily on technical feasibility rather than market demand, and are being pushed by industry and government agencies that “have a strong self-prophecy on the high penetration of DMB”.

Similarly, Carlsson and Walden (2007) discuss that mobile TV as a service could be related to Jenson’s (2005) notion of service design by “default thinking”, a mindset that combines “A weak collection of axioms of design, broad market visions, or rules of execution that are not clearly articulated”. Jenson uses the disappointing story of MMS as an example of such service design; the mobile industry first expected MMS to be instantly successful, because SMS was popular and because it would be even more “cool” to send photos as well. Jenson writes that while there indeed appears to be an intuitive value to sending a photo, additional questions need be asked, such as "Do people really need this?" and "What are they doing in their lives where this has significant value?" In our mind, asking these questions is appropriate as well in the mobile TV case – or put even more simply, “What is the customer ‘pain’ that mobile TV is solving?”

Moreover, in our thinking, any new form of entertainment or other information good will have to compete for the same limited wallets and time of consumers with all the existing ones: movies, TV, radio, CDs, MP3 players and other portable media players, newspapers, books, games, mobile Internet, and so forth. Therefore, reasonable pricing, availability of quality content, and ease of use can be vital factors for DVB-H to be attractive to consumers.

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Interviews

In alphabetical order:

Hoikkanen, Anssi. Research Engineer, Nokia Oyj.

Holopainen, Janne. Project Director, DVB-H; Digi TV Plus Oy.

Kallioja, Tapio. CEO, SWelcom Oy.

Kivisaari, Eino. Researcher, TKK Telecommunications Software and Multimedia Laboratory.

Kronlund, Jonas. Technology Manager, R&D; Elisa Oyj.

Mustonen, Juha. Vice President, MTV Interactive Oy.

Nieminen, Seppo. Business Development Manager, Digita Oy.

Pesari, Pekka. Development Manager, TeliaSonera Finland Oyj.

Rautio, Tarja. Business Development Manager, Digita Oy.

Valtanen, Jukka. Executive Vice President, Elisa Oyj.

Appendix A: Numeric results

The below tables list the NPV results for each operating model. Probability of positive NPV is the proportion of positive outcomes after 1,000 simulation runs.

Operating model 1: MNO approach

Results for MNO approach, simulcasts are free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	42.2%	-1.3	6.0
Average	3.2%	-9.6	5.2
Pessimistic	0.0%	-16.8	4.1

Results for MNO approach, simulcasts are not free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	95.6%	9.6	5.8
Average	54.7%	0.3	4.5
Pessimistic	0.8%	-8.5	4.2

Operating model 2: MVNO approach

Results for MVNO approach, simulcasts are free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	0.0%	-11.1	2.2
Average	0.0%	-12.6	2.3
Pessimistic	0.0%	-14.1	2.3

Results for MVNO approach, simulcasts are not free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	7.3%	-5.5	3.8
Average	0.3%	-8.9	3.5
Pessimistic	0.0%	-12.1	3.3

Operating model 3: Broadcaster approach (indirect)

Results for broadcaster approach, indirect, simulcasts are free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	100.0%	10.3	3.8
Average	32.6%	-1.8	3.5
Pessimistic	0.0%	-13.9	3.3

Results for broadcaster approach, indirect, simulcasts are not free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	99.7%	12.6	5.1
Average	60.9%	1.0	4.1
Pessimistic	0.0%	-10.7	3.7

Operating model 4: Broadcaster approach (direct)

Results for broadcaster approach, direct, simulcasts are free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	100.0%	13.2	4.3
Average	50.0%	-0.1	3.4
Pessimistic	0.0%	-13.2	3.4

Results for broadcaster approach, direct, simulcasts are not free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	99.9%	17.3	6.2
Average	80.0%	3.7	4.4
Pessimistic	0.1%	-9.2	3.8

Operating model 5: Pay-TV broadcaster approach (indirect)

Results for pay-TV broadcaster approach, simulcasts are free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	11.6%	-6.0	4.7
Average	0.1%	-11.9	3.9
Pessimistic	0.0%	-17.5	3.4

Results for pay-TV broadcaster approach, simulcasts are not free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	54.1%	0.5	5.3
Average	4.4%	-7.7	4.5
Pessimistic	0.0%	-15.3	3.6

Operating model 6: Co-operation approach (MNO)

Results for co-operation approach, MNO, simulcasts are free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	61.8%	0.4	2.1
Average	18.1%	-1.7	1.8
Pessimistic	0.3%	-3.7	1.7

Results for co-operation approach, MNO, simulcasts are not free.

Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	71.4%	1.2	2.3
Average	33.7%	-1.0	2.0
Pessimistic	1.7%	-3.3	1.9

Operating model 7: Co-operation approach (MVNO)

Results for co-operation approach, MVNO, simulcasts are free.

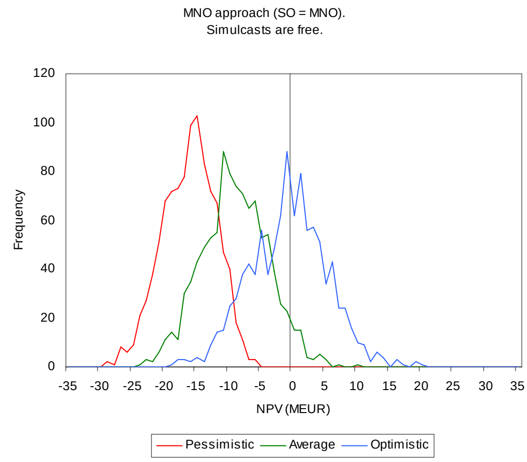
Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	0.7%	-3.5	1.7
Average	0.0%	-4.4	1.7
Pessimistic	0.0%	-5.1	1.7

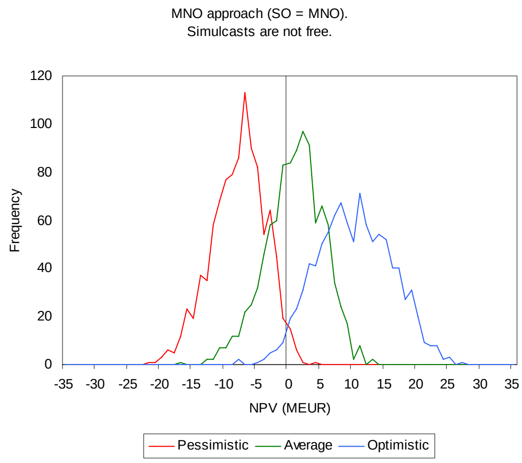
Results for co-operation approach, MVNO, simulcasts are not free.

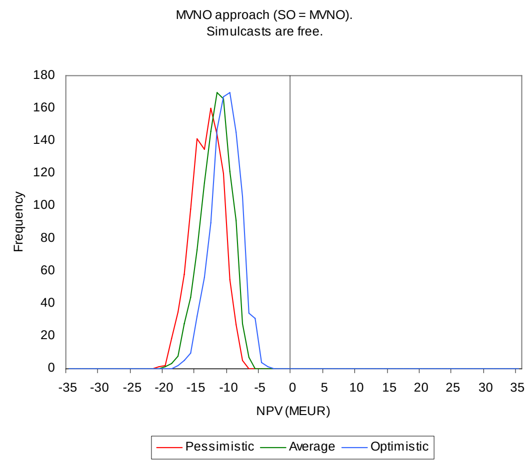
Forecast model	Probability of positive NPV, %	Mean NPV, MEUR	Standard deviation of NPV, MEUR
Optimistic	2.1%	-3.2	1.8
Average	0.0%	-4.3	1.8
Pessimistic	0.0%	-5.0	1.7

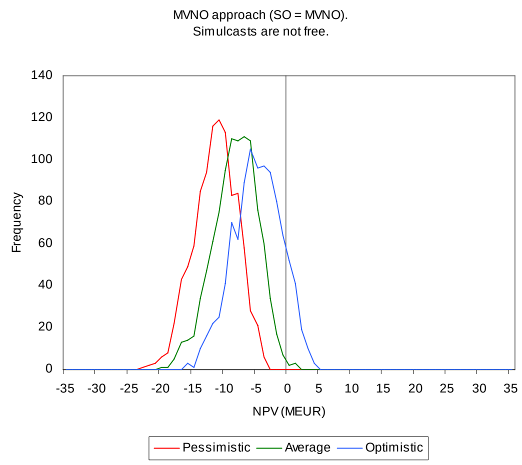
Appendix B: Density distribution of NPV

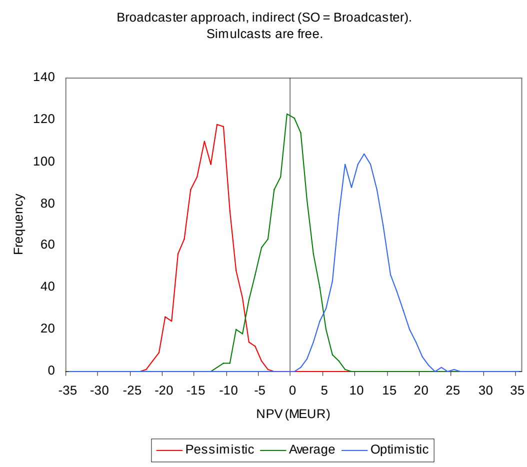
The 14 figures below show the statistical density distributions of NPV results for each of the 42 calculation cases after 1,000 Monte Carlo simulation runs.

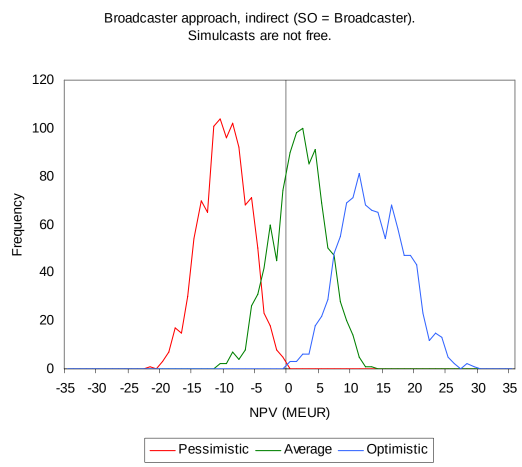




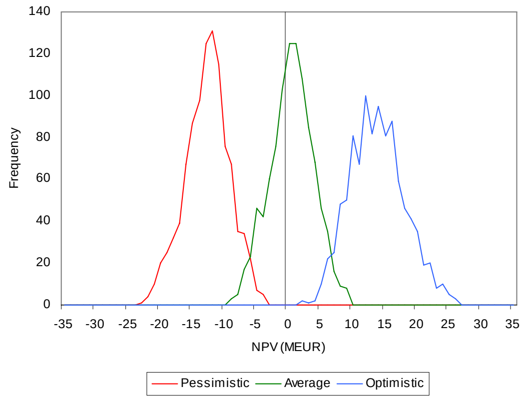




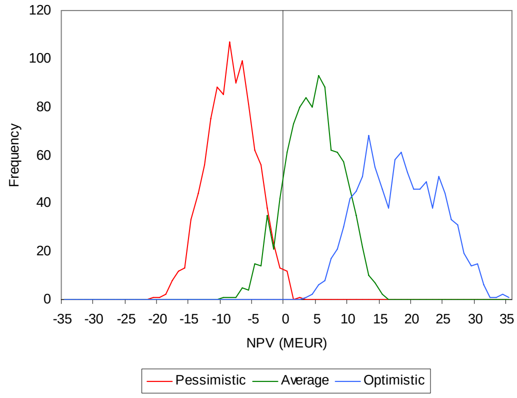




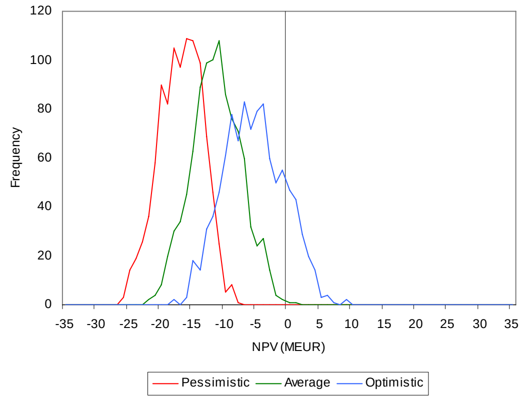
Broadcaster approach, direct (SO = Broadcaster).
Simulcasts are free.



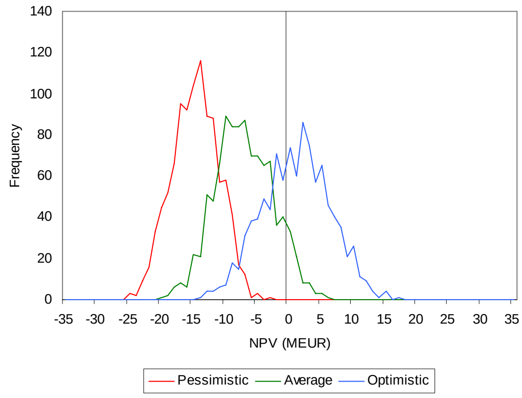
Broadcaster approach, direct (SO = Broadcaster).
Simulcasts are not free.



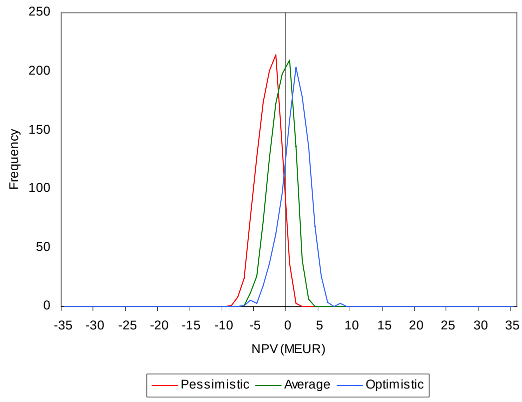
Pay-TV content aggregator approach (SO = Content aggregator).
Simulcasts are free.



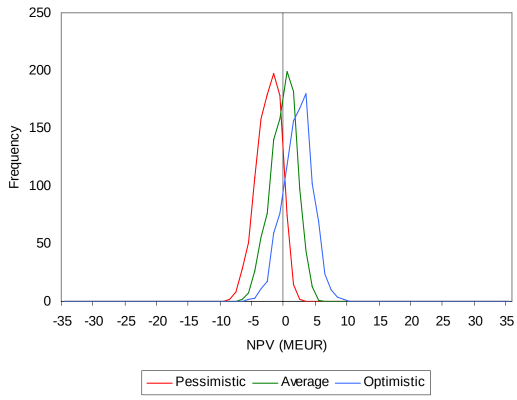
Pay-TV content aggregator approach (SO = Content aggregator).
Simulcasts are not free.



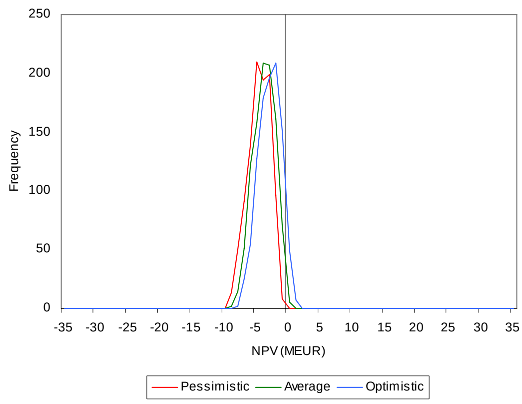
Co-operation approach (SO = MNO).
Simulcasts are free.



Co-operation approach (SO = MNO).
Simulcasts are not free.



Co-operation approach (SO = MVNO).
Simulcasts are free.



Co-operation approach (SO = MVNO).
Simulcasts are not free.