The Mobile Provide

Economic Impacts of Alternative Uses of the Digital Dividend

Methodology Report, September 2007

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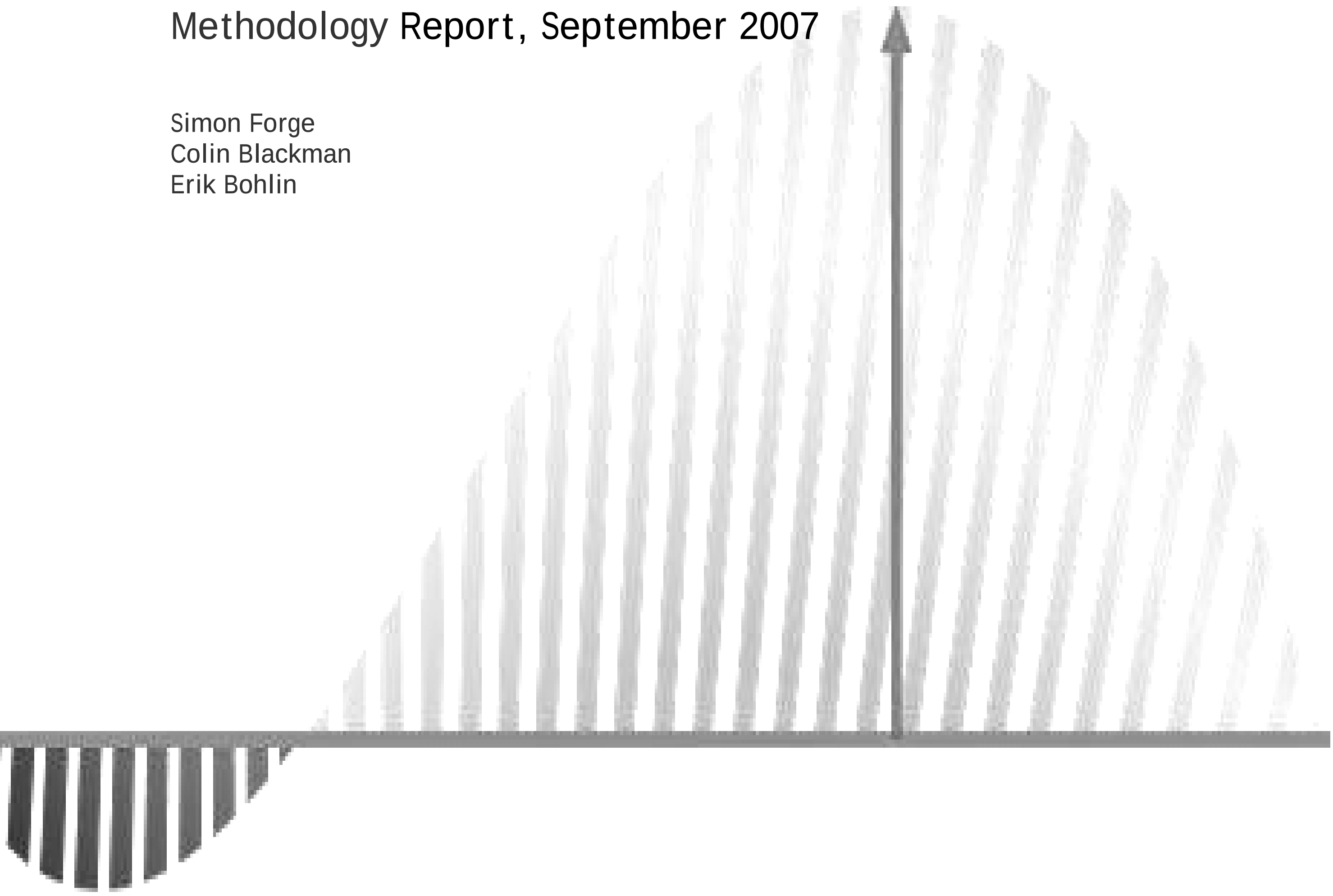

SCF Associates Ltd

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The views expressed in this report are those of the authors and do not necessarily reflect those of Deutsche Telekom or T-Mobile International.

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PREFACE

This report puts forward the methodology used in a study commissioned by Deutsche Telekom / T-Mobile International intended as input for preparation of assessments and decisions at a European level on the Digital Dividend. It forms part of our interim deliverables. The method is based on utilising a novel extension of existing approaches. It is the result of the initial phase of this study, carried out by a small team over a nine week period in May and June 2007.

1. A unique opportunity for Europe

1.1 The promise of the switchover to digital – the digital dividend

The switchover from analogue to more efficient digital TV broadcasting in Europe over the next five years will release significant spectrum in UHF bands.[1] This digital dividend could be used for a variety of purposes, including:

- local digital terrestrial television channels;
- additional national digital terrestrial television channels, in either standard definition or high definition;
- television services for mobile phones and other types of mobile video and multimedia;
- mobile communications, such as voice calls and data;
- broadband wireless applications;
- wireless microphones for theatres, television and radio production and live music events;
- low-power wireless applications, such as WiFi in the home; and
- public safety services, such as wireless communications for the emergency services.

European and national authorities are therefore considering proposals for how best to use this digital dividend and also how it should be allocated. The approach differs across the Member States, and depends to some extent on the relative influence of the various stakeholders and actors – broadcasting and media, telecommunications, equipment manufacturers, etc. Clearly the economic impacts of different uses of the spectrum will be key to deciding how such spectrum should be used, although other factors will be taken into account, such as social benefits, political objectives and the desirability/feasibility of European harmonisation or coordination.

It must be noted that the digital switchover presents Europe with a unique and historic opportunity to meet new demands for services and support innovation. Previous estimates from one Member State when extrapolated find that business activity which is largely dependent on the radio spectrum may contribute up to 3% to Europe's GDP[2] and the value of the digital dividend will be worth many billions of Euros over the next twenty years. The digital dividend will therefore have a significant impact on industry across the EU as well as being key to supporting the Lisbon's agenda's goal on job growth and competitiveness.

1.2 The key question for Europe's future society and economy

Consequently there is a key question today:

> *What will be the impact on the European economy of alternative uses of spectrum released through the digital dividend?*

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[1] Analogue switch-off has already begun in the Netherlands and the majority of EU Member States are expected to complete by 2010 and before the 2012 date set by the European Commission. Spectrum will be released in the 470-862 MHz bands and possibly others

[2] Ofcom has estimated the contribution to the UK economy is of the order of 3% of GDP.

This gives rise to several subsidiary questions concerning, for instance:

- the impacts of alternative uses of the spectrum on investment, innovation and employment
- efficiency gains in the mobile communications sector and, most importantly
- the opportunity to reduce the digital divide throughout the European Union

This study, commissioned by Deutsche Telekom/T-Mobile International, was undertaken to reply to these questions within the context of the proposed imminent release of analogue TV frequencies throughout the EU. Our interim findings, based on a novel extension of an established methodology, are the result of the first phase of the study which was carried out by a small team over a nine week period in May and June 2007

1.3 Objectives and scope of the study

The main task of the study is therefore to consider the economic factors involved in the digital dividend, from micro-economic to finally a macro-economic European level, and so construct a framework for assessment of their impact that can underpin future EU decisions on directions in this domain. In addition, this should:

- Provide a useful basis for drafting an impact assessment to accompany future proposals

- Address two areas to improve economic efficiency of radio spectrum management:

    - Provide insights for the liberalisation of spectrum use through the introduction of more freedom for alternative uses, following the principle of rising future demands for radio services and technology for all applications with the introduction of new spectrum for electronic communication services

    - Show the impacts of a coordinated, pan-European approach, improving the coherence of spectrum management across the EU, as necessary.

2. Our approach

Our need to consider the impacts of different spectrum allocation methods lends itself to analysis by multiple scenarios of spectrum allocation. In our experience, these kinds of issues are best explored through construction and consideration of alternative scenarios which may characterise each set of conditions clearly, so contrasts are drawn out. Therefore the conceptual orientation and methodology of the study is to use a comparative assessment between different future options for the EU relating to spectrum assignment and service provision as two main steps:

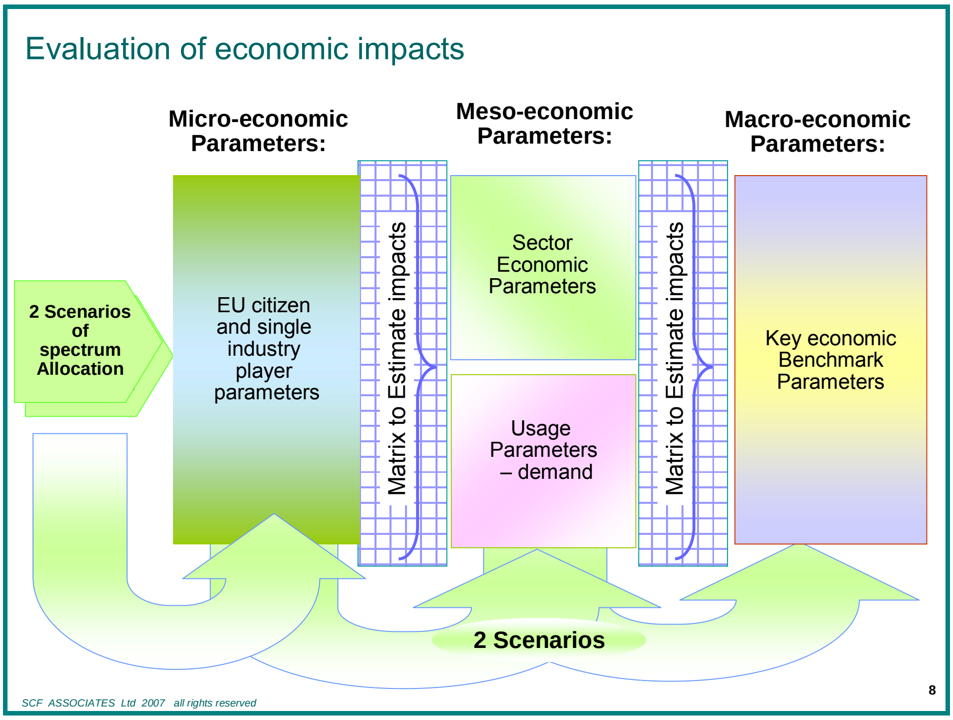
- Carry out an empirically based scenario exercise on spectrum use with the Digital Dividend
- Analyse immediate and longer term effects in terms of economic efficiency for investment, innovation, employment and deployment in a single EU information space.

From these scenarios, various impacts can be investigated, with the potential for economic advantages for Europe of each of the various alternatives.

2.1 Methodology - Micro to Meso to Macro linkages

The project rests on the conceptual assumption that it is meaningful to connect decisions made by firms, households and individuals to aggregate outcomes on sector and industry levels, as well as on national and super-national aggregates. The figure below sets out how the variables in the project are interlinked and aggregated:

Figure 2.1. Overall methodology for the study



This assumption is justified both from mainstream and innovation based economics. For the former, for some time a wide conceptual separation existed in the field between micro-economics and aggregate macro-behaviour, in the wake of the Keynesian revolution in the 1930s and its aftermath. However, already since the 1970s, there have been several developments in mainstream economics to remedy this separation – in particular from the so-called rational expectations school (led by Robert Lucas) and the so-called neo- and new Keynesian economics (among which the most visible proponents are Paul Romer, with his 'new growth theory'). Basically, the old Keynesian approach in which the macro-economic policy advice was centred on a few stylized equations without micro-based behavioural assumptions is outdated. Similarly, in innovation based economics, there has developed a long-standing tradition of linking the micro-based decisions with aggregate outcomes, for instance by Richard Nelson and Sydney Winter in their theory on evolutionary economics[3].

The term 'meso economics' has been developed primarily by researchers active in innovation economics, to denote the intermediate level between the polar types micro and macro. As Dopfer (2006) explains, Joseph Schumpeter was the principal source of the micro-meso-macro analysis, by advancing the proposition that entrepreneurs carry out innovations (the micro level), that swarms of followers imitate (meso) and that, as a consequence, 'creative destruction' leads to economic development 'from within' (macro).[4] For the purposes of this paper, with its emphasis on the dynamic impact of the digital dividend, the conceptual linkage with the Schumpeterian tradition is fitting.

Even though it may be conceptually appropriate to postulate linkages between the micro-meso-macro levels, several measurement problems may accrue. A case in point is the debate that followed the so-called 'Solow Productivity Paradox', identified in 1987.[5] The paradox generated a sizeable number of research papers in the 1990s in which the dominant conclusion was a time-lag in productivity effect, coupled with measurement constraints.[6] A novel, more recent explanation is that the productivity impacts from ICT came much earlier than other historical examples of general purpose technologies (such as steam and electricity), and that "the true productivity paradox is why economists expected more sooner from ICT".[7]

In the context of our study, the relatively quick resolution of the Solow Productivity Paradox suggests that while there could be lags in the statistics, our framework and approach does not pose any conceptual or methodological problem in principle. Rather, the conclusion of the Solow Productivity Paradox debate serves to strengthen the hypothesis that investments in ICT will improve GDP.

We implement our approach using two scenarios to simulate the impacts of different forms of spectrum allocation. Their impacts can be viewed as acting at the micro-economic level of

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[3] Nelson, R, Winter, S, *An Evolutionary Theory of Economic Change*, Harvard University Press, 1982 - the landmark reference on evolutionary economics with a simulated approach. It has generated a large volume of literature - for instance, see: http://www.sussex.ac.uk/Units/spru/publications/imprint/sewps/sewp83/sewp83.pdf; http://www.druid.dk/conferences/nw/; another important author is this vein is Giovanni Dosi, who combines a micro-based approach with aggregate and sectoral analysis, using both statitstical analysis and simulation, as well as theory development (see http://ideas.repec.org/e/pdo10.html for recent papers).

[4] Dopfer, K. (2006), *The Orgins of Meso Economics: Schumpeter's Legacy*, Papers on Economics and Evolution, No. 0610, Max Planck Institute , Papers on Economics and Evolution, Evolutionary Economics Group, MPI Jena;, and Emilio Fontela, 'From the wealth of nations to the wealth of the world', *Foresight*, Vol 4, No 1, 2002.

[5] The paradox followed from the remark: "You can see the computer age everywhere but in the productivity statistics." (Robert Solow, *New York Review of Books*, July 12, 1987), quoted in Triplet, J., 'The Solow Productivity Paradox: What do Computers do to Productivity?', *Canadian Journal of Economics*, Vol 32, No 2, April 1999, pp 309-334.

[6] See Brynjolfsson, E., Hitt, L., (2003), *Computing Productivity: Firm-Level Evidence*, MIT Sloan Working Paper, No. 4210-01, for a more recent paper with sizeable reference list. A convincing argument for time lags are made in David, P. A. (1990), 'The dynamo and the computer: a historical perspective on the modern productivity paradox', *American Economic Review*, Vol 80, No 2, pp. 355-361.

[7] Crafts, D., (2002), *The Solow Productivity Paradox in Historical Perspective*, CEPR Discussion Paper 3142, Stanford University

the individual, then at sector and social or meso-economic levels, which are linked to macro-economic levels.

Using a model of development based on careful selection of parameters, with multiple scenarios, we attempt to assess the impacts of future spectrum regulation allocations on the economy and the telecommunications environment (its industry and market). In essence, our modelling approach consists of:

1. *Scenario building*
First, we have constructed scenarios, using the SCF approach, explained in more detail below, of a key theme and initial key drivers, with known initial conditions to yield the assumptions, assertions, leverage points, hypotheses, points of doubt and inaccuracy and finally the scenarios..

2. *Constructing the model*
A quantitative model may also be constructed, based on the scenarios, by using chosen parameters and analysing their behaviour across the three economic levels. We use correlation matrices to give the links for a composite structure of dependence, across the three levels of economic scale. This requires building the model as a set of dependent variables, following the correlation coefficients, to which the baseline data can be applied, and then modulated by the scenarios.

3. *Applying the data and exercising the model*
Historic data gathered to give the status quo acts as the starting point. Projection by scenario of the data can then be applied to the chosen parameters. From the scenarios' influence on the key parameters at each stage of the model we can see the outcomes, finally at the macro-economic level.

We would note that in calculating the forward time series for the quantitative economic model we use more than simple extrapolation of time series from past series. Although simple forms of extrapolation may be a useful start-point, they may not give a useful baseline on which to demonstrate differences by scenario. We therefore add shaping functions which give a limiting or boosting effect, based on expected outcomes for a neutral or baseline case. These are largely heuristic - based on experience of either known market behaviour of major players, or, of expected events, including those of the scenario. An example of an event might be take-up of mobile VoIP with its anticipated impact on pricing, user spend and ARPU. Such an approach enables us to introduce market rules or trends to an evolving future scene, rather than to rely purely on mathematical abstractions. We are conscious that to some extent the latter have been heavily criticised in realistic business circles in the past as producing non-causal interventions. These have sometimes collectively termed 'driving in the rear-view mirror' in that they rely on past time series overmuch; so we are anxious to restrict use of such techniques. An extreme instance is forming a baseline for GDP growth (one of the most difficult tasks) using simple extrapolation of continued GDP growth from several years of positive growth would be unreal, it would forecast continued expansion forever – instead it should be limited and/or decline at some point, based on decisions from experience, and /or common initial conditions.

2.2 Scenarios and their justification

We have used a tried and trusted method – Scenarios Construction for Forecasting[8] – to build two scenarios, which are described in Chapter 3. Here we give an overview of the scenario building method.

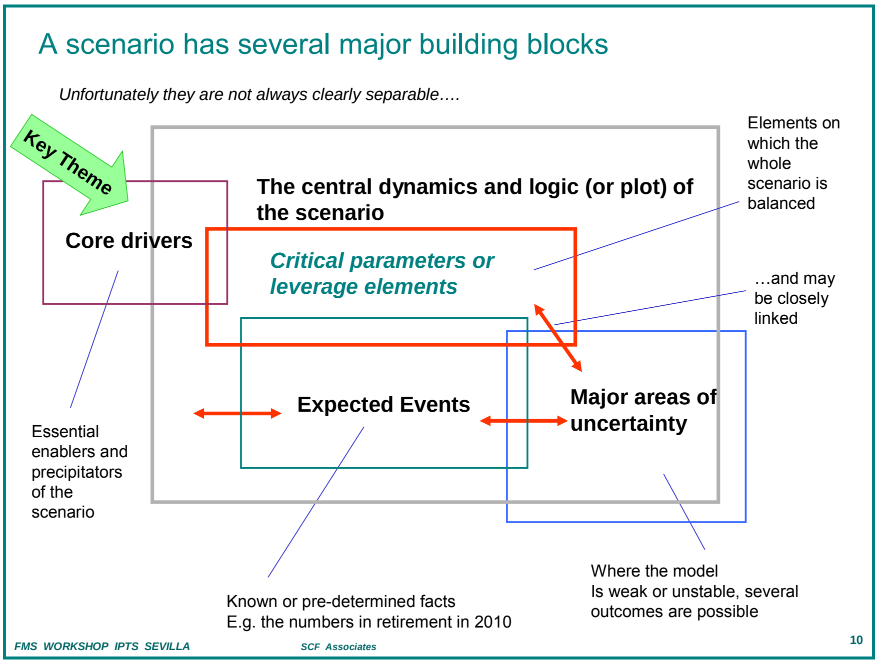
[8] Scenario Construction for Forecasting is a method developed and used by SCF Associates for more than 15 years in policy and business strategy, especially for telecommunications and mobile studies. A few examples are as follows: for a large successful systems vendor it provided inputs to guide global strategy at three major turning points in its development over twelve years; it was used in the Future Mobile Services study (FMS) for DG/JRC/IPTS to build a common European position for the ITU WRC-07 deliberations and, subsequently one scenario was modified and adopted within the ITU; it was used to support the impact assessment on spectrum allocation methods for DG InfSo in 2006 (note this study is not yet public). The contribution of the FMS study was

Planning with scenarios has the aim of bringing together useful future views with events, attitudes, surroundings, new forces and players. Scenarios should not be seen as predictions as such but a supposition of what might happen in certain circumstances. They cannot forecast exact outcomes in economies or technologies. But they do offer a perspective to provoke 'what if' analysis, to discuss and identify the relevant factors and directions.

In a scenario, we combine two worlds – a world of future perceptions, usually centred on a theme or significant change – and the world of plain facts. We can build several pictures of a specific domain of interest in which hypotheses can be set out to obtain a range of future views – a small set of contrasting stories about the future. Each scenario must be noticeably and fundamentally different in some explicit way to be valuable. Scenarios should be as convincing, yet as startling, as possible because the expected is often not reality, and should incorporate all the chaos and complexity of the real world.

They attempt to involve every element that it is relevant and practical to incorporate, as naturally as possible, to construct daily life at some or all of the three levels of personal, corporate and national/global environments. These elements will be included in the premises of the scenario, perhaps as initial conditions and expected events. From this preparation, a scenario can be constructed via a set of standard components of facts and logic as shown below, including core drivers, the dynamics of the 'plot' and identifying weaknesses and areas of uncertainty (see Figure 2.2).

Figure 2.2. Constructing the scenarios



In particular, the real forces of change must be identified – be they widespread and long term or specific and short-term, eg the increasing youth segment in the developing world (to be 40% soon); or that OECD populations will age faster; or the rise of the NICs (newly industrialised countries) which will dominate the global economy by 2020 - by 2015, China may represent 20% of the global GDP, up from 3% in 1980. The process of scenario formulation used here follows a series of steps, in a formalised approach, Scenario

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acknowledged in the recent Communication on The ITU World Radiocommunication Conference 2007 (WRC-07). COM (2007) 371 final, 2 July, on page 5: "One of the main inputs into the ITU analysis was a study for the European Commission on spectrum requirements for Future Mobile Services".

Construction for Forecasting, built up over a decade of large studies looking and macro and micro-economic affects of telecommunications on the economy and industry segments.

Effectively, the method formalises the creation of alternative scenarios by trying to rationalise and understand the mechanisms of possible change and potential rates of change through:

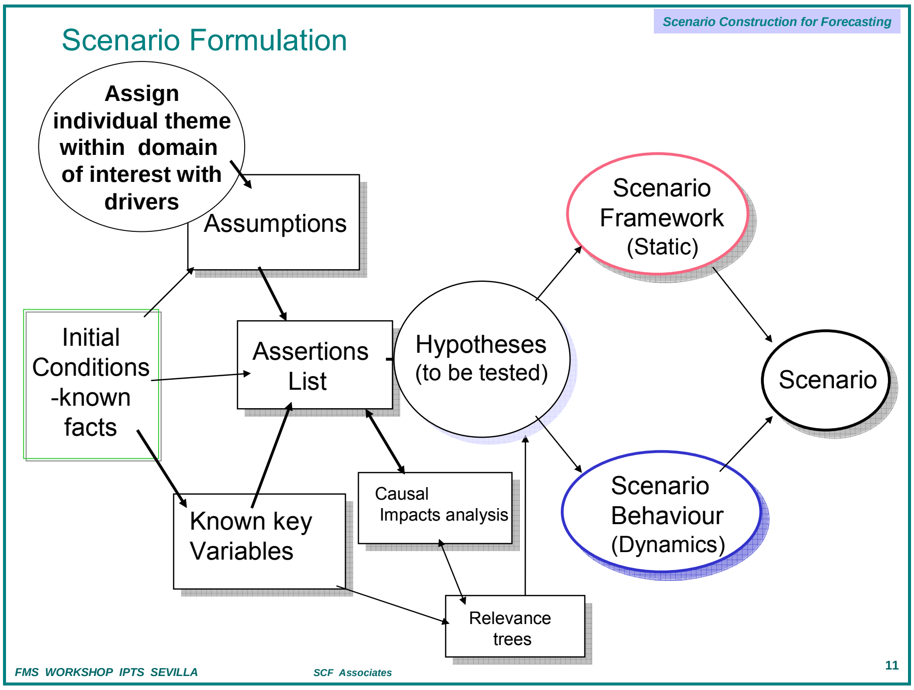
- Identification of key parameters, leverage points, triggers and long term trends
- Including the impacts of major discontinuities –likelihood and secondary effects
- Use of causal effect chains, wherever possible, and their relative strengths, to form an overall impact analysis, of both external forces and internal
- Building the central logic of the scenario (the plot) as a framework and dynamics. This may centre on a basic theme, issue or decision (e.g. oil at $100/barrel).

Thus each scenario requires a distinct 'theme' or basic premise, one that is singular and also relevant to the subject area of interest. Initial conditions that drive all of the scenarios are also considered at this time and may affect the choice of themes. Assumptions can then be made. From all of this come simple assertions. With the assumptions, they may be grouped into more adventurous and encompassing Hypotheses, from which the framework and plot dynamics of the scenario can be derived. The main stages of scenario construction are:

- Firstly give each scenario its distinctive 'theme'. This may be an iterative process with the gathering of assumptions and also with the forming of a set of known facts that will be true across all scenarios, as initial conditions.
- Assumptions are listed, possibly shaped by the one central theme or issue (for example a "what if") based on surmises of ways markets, social factors technology, economic forces, politics, physio-geographic situations may go.
- Then, which are the real key variables (including the unknowns) for this scenario are decided - values now and in the future for the knowns, are included. These first stages may take some effort and time, as to what is both significant and relevant.
- From these inputs, simple assertions can be made about the scenario (almost one line sentences) and the causal effects and interworking are can be checked and traced in an impact analysis, perhaps with use of a relevance tree for secondary and interlinked impacts. The inter-relationships and dependencies are reviewed.
- Simple hypotheses can then be formed as the foundation of a scenario, for instance, the roles of key actors, based on the above; they are then reviewed.
- All the relevant hypotheses are then combined to build a scenario's "plot" – its framework and dynamic behaviour; further reviews can then identify weak points.

An outline of the overall process is shown in Figure 2.3:

Figure 2.3. Scenario formulation



In this way, two scenarios were developed:

- Scenario 1: Most of the dividend is used for additional digital terrestrial channels and HDTV
- Scenario 2: A significant proportion of the spectrum is released via a licensed spectrum regime for advanced mobile communications services

These scenarios are described in detail in Chapter 3.

2.3 The choice of parameters

Like any kind of industrial development, the growth in industries producing ICT goods and services is thought to be important to the growth of the economy. But as many other researchers have found, measuring the impact of any kind of information and communication technology is difficult, due to problems of identifying linkages between these economic inputs and their impacts. We have already noted the difficulty of finding evidence of a direct impact of ICT on economic activity, the so-called Solow Paradox.[9] The picture is similar for communications, although it has long been held that there is a correlation between telephone use and GDP,[10] and recent research by Leonard Waverman has shown a correlation between mobile telephony and the economy[11] while Erik Brynjolfsson has shown evidence[12]

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[9] For references and more extensive discussion, see section 2.1.

[10] Andrew P. Hardy, 'The role of the telephone in economic development', *Telecommunications Policy*, Vol 4, No 4, December 1980, pp 278-286.

[11] Leonard Waverman, Meloria Meschi and Melvyn Fuss, 'The impact of telecoms on economic growth in developing countries', http://web.si.umich.edu/tprc/papers/2005/450/L%20Waverman%20Telecoms%20Growth%20in%20Dev.%20Countries.pdf

[12] Brynjolfsson, Erik and S. Yang, (1996), 'Information technology and productivity: a review of the literature', *Advances in Computers*, 43, pp. 179-214; Sinan Aral , Erik Brynjolfsson and D.J. Wu, *Which Came First, IT or Productivity? The Virtuous Cycle of Investment and Use in Enterprise Systems* , MIT Center for Digital Business Working Paper, October, 2006; and, Brynolfsson, E. and Kahin, B. (eds) (2001), *Understanding the Digital Economy*, MIT Press, Cambridge.

for computerised working and gathered references in the literature on the role of computing in productivity.

Perhaps of more importance, socially and economically, are the indirect impacts of the diffusion and use of ICTs, which has the ability to transform the way individuals, businesses and society interact, work and communicate. But measuring indirect benefits is even more difficult. The latest *ITU World Telecommunication/ICT Development Report* notes:[13]

> One way of understanding the difficulty of measuring the impact that ICTs have, is to imagine the impact that electricity has had on the economy and society. As with ICTs, there is no denying that electricity has had important impacts on individuals, businesses and society at large but its measurement is elusive.

Clearly the choice of appropriate parameters as indicators for measurement is one of the keys to this study. Our choices have been guided by several factors – by the desire to make a methodological advance in quantitative forecasting, by the literature on measuring impacts of ICTs, and by good practice in impact assessment in keeping with the concept of SMART objectives, the principles of which are set out in the box below:[14]

> **Objectives should be:**
>
> **S**pecific: Objectives should be precise and concrete enough not to be open to varying interpretations. They must be understood similarly by all.
>
> **M**easurable: Objectives should define a desired future state in measurable terms, so that it is possible to verify whether the objective has been achieved or not (see III.6). Such objectives are either quantified or based on a combination of description and scoring scales.
>
> **A**ccepted: If objectives and target levels are to influence behaviour, they must be accepted by all of those who are expected to take responsibility for achieving them.
>
> **R**ealistic: Objectives and target levels should be ambitious – setting an objective that only reflects the current level of achievement is not useful – but they should also be realistic so that those responsible see them as meaningful.
>
> **T**ime-dependent: Objectives and target levels remain vague if they are not related to a fixed date or time period.

With this in mind we have constructed a quantitative approach to complement the scenario building. We would note however that the accuracy of the results must be taken as indications of trends and no more.

Thus, our initial analysis enabled us to make a selection of parameters at a general level, as follows:

- Micro economic parameters: user / demand side
- Meso economic parameters: Sector penetration by unit sales to indicate take-up etc
- Meso economic parameters: Infrastructure penetration
- Meso economic parameters: Revenues
- Macroeconomic parameters: Employment, GDP, etc

We then spent significant time in researching the availability of data to support possible parameters (see section below on sources of data) before we drew our conclusions on which parameters were proportionate to policy objectives and which were appropriate and could be worked with in the context of this study. From previous work we have also used the guidance

[13] ITU, *Measuring ICT for Social and Economic Development*, World Telecommunication/ICT Development Report 2006, http://www.itu.int/pub/D-IND-WTDR-2006/en
[14] European Commission, *Impact Assessment Guidelines*, SEC(2005) 791, June 2005, p 20.

on the efficacy of such parameters through a limited survey a small selected group of industry and socio-economic experts. This process both stimulated ideas for other parameters and also focused attention on the ease and likely availability of data. The final list of parameters chosen is shown in Table 2.1:

Table 2.1. The list of parameters chosen

Micro-economic parameters: Consumer expenditure on communications and media	**Meso-economic parameters: Growth of media and wireless sub-sectors - penetration of TV receivers and mobile handsets in EU27**	**Macro-economic parameters: EU GDP and Employment**
1. Mobile ARPU, US$, EU-27	1. Growth of wireless industries (WiFi hot-spots)	1. EU GDP growth rate
2 TV spend as %age of total household spend on e-comms	2. Millions of TV receivers	2. GDP/head (Euros/inhabitant)
3 Internet/BB spend as % age of total spend	3. TV revenues	3. EU Employment
4 Mobile spend as % age of total spend	4. Handset Sales	4. EU Employment in services as %age total employed
	5. Revenue from mobile communications	

At each level, parameters were calculated for forward simulations over 2007 to 2020.

2.4 Data sources

As has already been indicated, the choice of parameters was strongly influenced by the availability of data, which had to have a number of characteristics. To be suitable and useable in this study, data had to be available ideally:

- for the whole of the EU-27, or failing that for EU-25, or even for the EU-15. Often we found that some promising data sets were only haphazardly collected and available for a partial set of Member States. Often Eurostat data is still only available for the EU-15. OECD data, which is generally good, is not categorized for the EU but can sometimes be used to fill in gaps or confirm Eurostat data.
- as time series data over several years, eg 2000-2006, or at least enough to allow interpolation to build a reasonably robust time series.

Thus the major sources of data consulted included databases from:

- Eurostat
- OECD
- ITU World Telecommunication Indicators Database
- World Bank
- UNCTAD
- EITO

Also the input data and processing has been augmented by several other sources for both quantitative data and qualitative shaping, including:

- The Work Foundation
- Reports on economic impacts of mobile communication for Ofcom, GSM Association, O2 and Vodafone
- Industry data, eg from Strategy Analytics, IDATE
- Academic papers: Maliranta and Rouvinen, 2006; Hazlett, Muller and Munoz, 2006; Mourik, 2003.

- European Commission documents, eg *The Economy of Culture*, DG Education & Culture

Our final list of parameters and the sources of data used are shown in Table 2.2:

Table 2.2. Data sources for the chosen parameters

Micro-economic parameters	Data source
1. ARPU per EU subscriber	ITU World Telecommunication Indicators Database; OECD, Communications Outlook, 2005;Teligen, Telecom Price Developments from 1998 to 2005, Report December 2005
2. TV spend as %age of total household spend on e-comms	Eurostat, household expenditure: Ofcom, International Communications Market Report, 2006
3. Internet/BB spend as % age of total spend	Eurostat, household expenditure; Ofcom, International Communications Market Report, 2006
4. Mobile spend as % age of total spend	Eurostat, household expenditure; Ofcom, International Communications Market Report, 2006

Meso-economic parameters	Data source
1. Growth of wireless industries (WiFi hot-spots)	WiFi hot-spots, jiwire http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm
2. Millions of TV receivers	ITU World Telecommunication Indicators Database
3. TV revenues	Ofcom, International Communications Market Report, 2006
4. Handset Sales	Strategy Analytics, 2006
5. Revenue from mobile communications	ITU World Telecommunication Indicators Database; OECD Communications Outlook

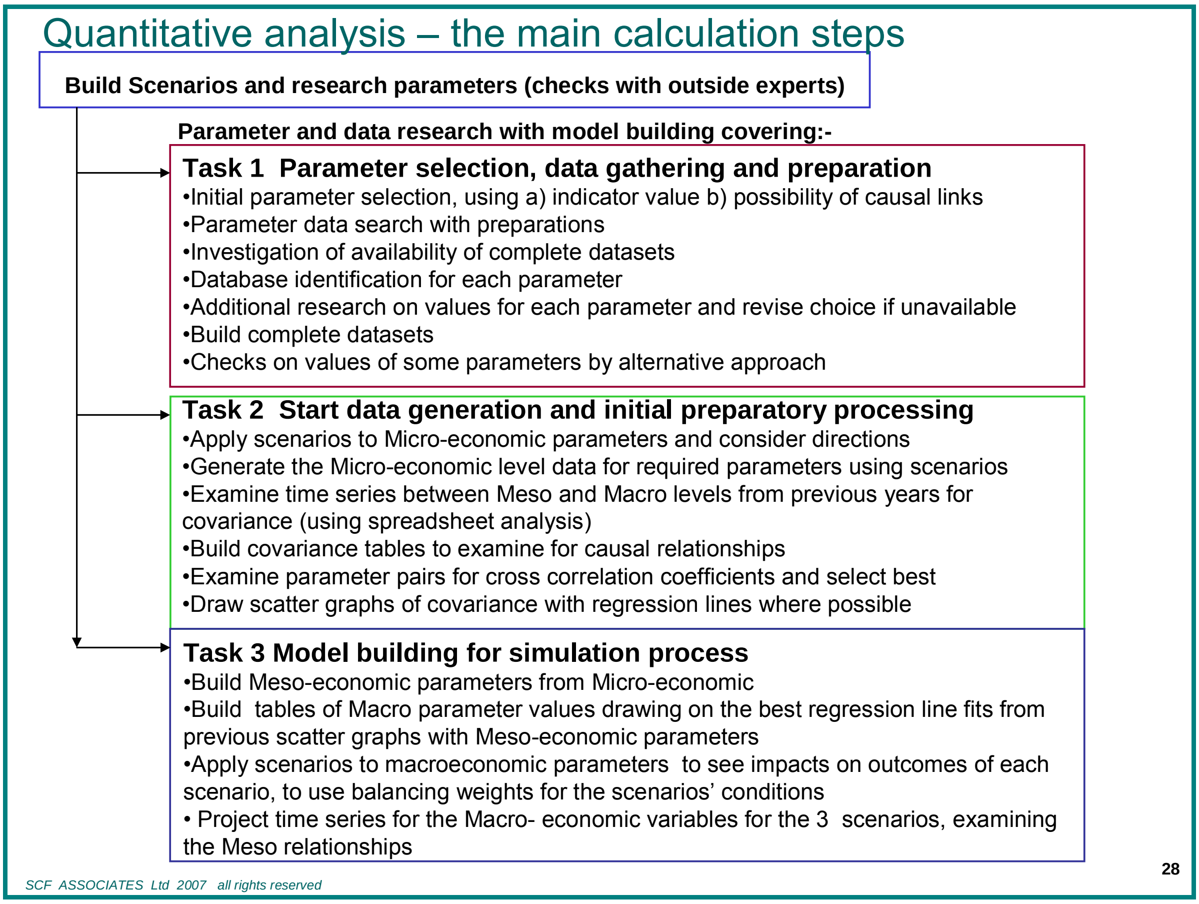
Macro-economic parameters	Data source
1. EU GDP growth rate	Eurostat; World Bank
2. GDP/head (EU25)(Euros/inhabitant)	World Bank, OECD, Eurostat, ITU
3. EU Employment	Eurostat
4. EU Employment in services as %age total employed	Eurostat, Work Foundation

NB: Owing to incomplete data in some time series we have used extrapolation and interpolation to make best estimates. Inevitably this detracts from the accuracy of the results.

2.5 The main steps in the calculation process

Our approach has been to take the above steps and combine them into a complete calculation process as shown in the flowchart below. It includes the steps of data acquisition and preparation before generation of the time series tables for the parameters at the three levels of economic aggregation using linking coefficients:

Figure 2.4. Flowchart for the overall process for calculations



In more detail, for tasks 2 and 3, the process for forward estimation is described in Box 2.1, building up the times series across the three levels of economic aggregation.

Box 2.1. Process for forward estimation

1 From historic series samples of Micro- economic and Meso time series parameters, use covariance between each pair to build ideas of causal relationships between Micro and Meso parameters

2 Draw scatter graphs with regression lines across Micro and Meso

3 Generate cross correlation coefficients for the Micro-Meso Matrix and choose the highly correlated pairs for use for projections forward of Meso time series

4 Generate each Micro parameter time series going forward to form the Base Case with simple curve fit based on behaviour assumptions from historical time series (Future 1 series)

5 Implement each Scenarios' impacts on each future Micro parameter time series, using a scenario modulating function with time that is appropriate (Future 2 series) for each type of variable (mobile, media, Internet)

6 Using the chosen Micro time series from the cross-correlation matrix, generate future Meso time series via regression lines with shaping functions to meet particular trend conditions for each variable type

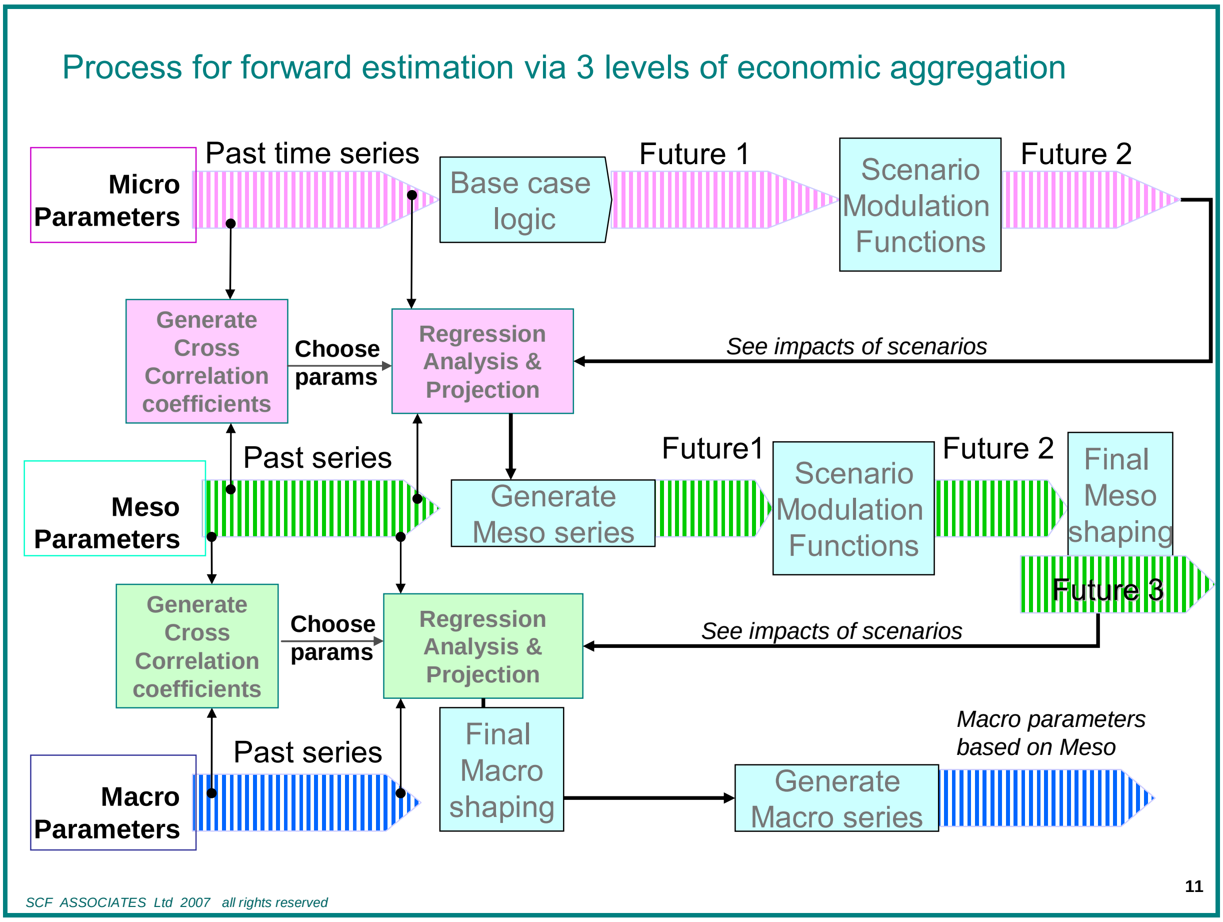
7 Repeat steps 1 to 6 for Meso to Macro series, incorporating any extra shaping functions in the macro parameters that come from trends in the literature (eg influences of mobile on productivity)

The above approach is straightforward but requires a number of spreadsheets to be constructed covering:

- Time series for each parameter- the original past history of these may stretch over 5 years at least and was drawn from the original sources. These are used to give trends and histories for future time series in simulations by scenario
- Linking tables or matrices for parameters, to show any relationships
- Charts for scatter diagrams of pairs of parameters, from appropriately prepared tables
- Preparation tables for derivatives of time series using simple difference equations
- Preparation of covariance series
- Preparation of correlation coefficients from co-variance series of calculations

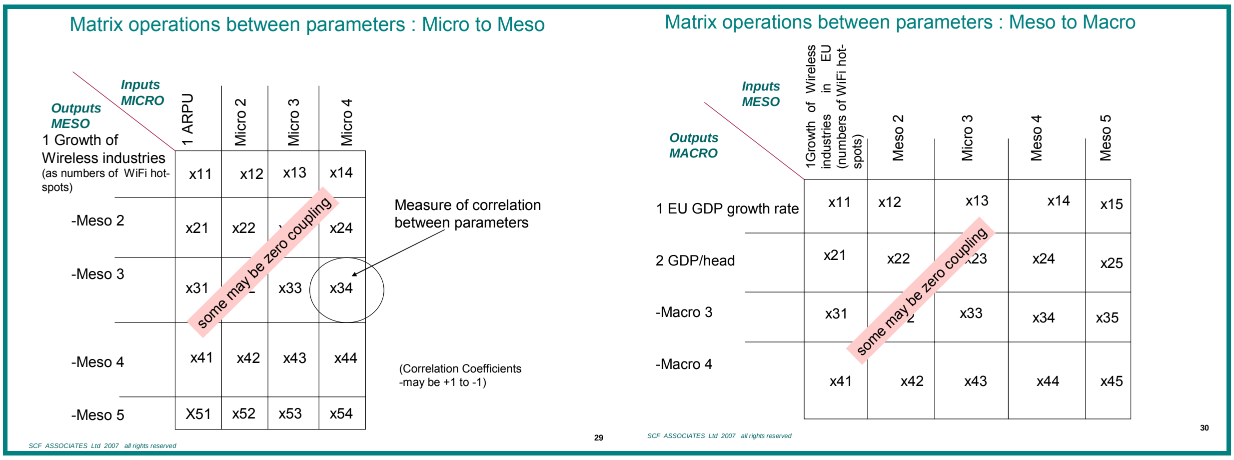
The overall logic in the spreadsheets of the calculation process can be depicted as a flow chart as follows:

Figure 2.5. Overall approach with scenarios both driving and linking levels of aggregation



Each level of aggregation is connected by a coefficients matrix (see Figure 2.4). Its elements are based on simple time series aggregations of the input time series elements, weighted to modify the form of the output time series according the impacts dictated by the scenarios. This weighting can vary from a simple constant multiplier that changes between scenarios (eg an extra x% linear growth per annum for a growth scenario, which may be made zero for a stagnation case) and/or simulation of a non-linear form such as an S-curve, with early fast growth tailing off in later decades, by using an inverse relationship with time.

Figure 2.6. The cross parameter matrices for Micro to Meso and from Meso to Macro



In essence these types of quantitative approaches supplement the qualitative approach of the scenarios, and lend themselves to comparative analysis, in that we can combine the simulations of possible events with what has actually happened, in a measured way.

3. Description of scenarios

3.1 Introduction

Economic models on their own are insufficient to analyse impacts of different spectrum uses because they omit the environmental conditions in which complex interactions occur. For instance, different players may have different agendas and goals, some to preserve the status quo, some to obtain better services or business conditions in their view. So important issues which scenarios must address include:

- What are the overall market impacts of the different spectrum allocation choices?
- What are the positions of consumers and the operators, both existing and new entrants?
- What technologies and services may be offered with what service level?

The two scenarios considered here differ in several key areas related to subsequent commercial exploitation.

3.2 The scenarios

Two scenarios were selected for their contrast:

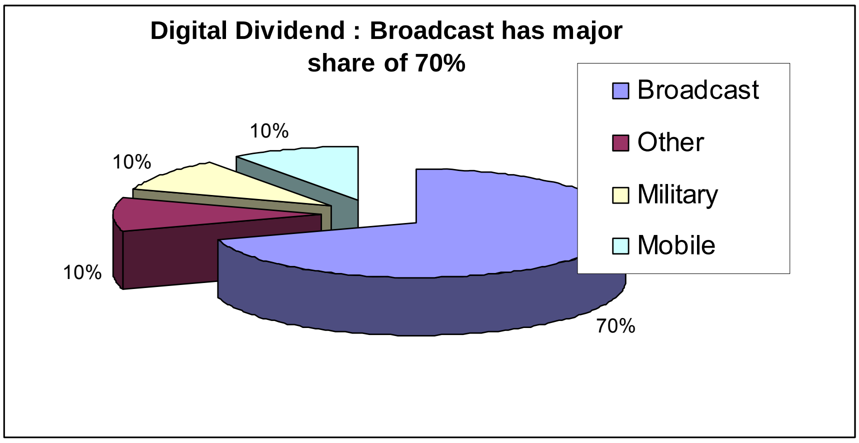
Scenario 1: Broadcast Media Rules – more for HDTV

Scenario 2: Mobile Bazaar – a lively, competitive market

Scenario 1 - Broadcast Media Rules

Theme: Most of the spectrum released as digital dividend is used for additional digital terrestrial channels and HDTV. No contribution is made to reducing the digital divide. The proportions of spectrum allocation for each allocation type are shown below:

Figure 3.1. Spectrum allocation proportions for scenario 1



Key drivers

- Government fear of media
- Move to next generation of TV technology - digital
- Struggle by incumbent broadcasters to maintain place in a changing world of new audiences, delivery platforms, media demand and technologies
- No free unfettered consideration of spectrum usage
- Demand for equality of access from media incumbents (for their own HDTV)
- Attempts at entry by new players, some with new technologies
- Other special interest groups individually weak (although together might be a loud enough voice)

Assumptions

- The media lobby wins through its close attachment to government as the voice of politics convinces top ministers that it should retain the newly released spectrum
- Social argument is the need for HDTV and exclusion for terrestrial subscribers if not as – satellite & CATV will have it thus terrestrial ‘needs’ it too
- Likely to be allocated through grace and favour, not auctions – so returns to government far lower than for mobile auctions

Assertions

- Satellite and cable are better placed to deliver any new digital services such as HDTV so broadcast is in a weak position technically, but not politically
- Terrestrial- broadcasters will plead their need to spend on new HDTV technology and so expensive licence fees out of the question
- Economic returns to government in terms of spectrum will be none or low if tendered to terrestrial broadcasters – not as high as expected as terrestrial operators already well-placed and mobile operators would pay more
- Smaller interest areas of 2 types will be squeezed out –
  - communities – special interests eg disabled – definitely squeezed out in auctions – but may have some managed allocation
  - special mobile services to meet social needs – e-health, e-Education, first responder emergency services, e-government, etc
- Moreover there is the new spectre of many new competing delivery mechanisms, whose potential will be ignored:
  - web-TV, a further candidate for broadcast services over broadband networks be they fibre or radio-based
  - IPTV programming via VDSL (some telcos have invested here, having sold off their cable networks and gone into partnership with IPTV technology suppliers).
  - Broadcast mobile schemes –DVB-H, T-DMB, ISDB-T, Qualcom Mediaflo, etc
- Hence this is a ‘Me-Too’ strategy and so may seem illogical for a new and expensive technology for which demand is not evident: it is uncertain that the target customer base will want to spend any money on it directly. What is left is a political drive and the decision will be political, not economic but without proven social benefit.
- So reserving spectrum for high-definition TV services on terrestrial broadcast, via dominant channels or Freeview and/or for local TV services must consider:
    - the impact of the proposals on the programme-making and special-events (PMSE) sector, principally users of wireless microphones;
    - the timing of releasing channel 36 (590-598 MHz); and
    - holding spectrum back from the award for possible future innovations and/or for low-power applications
- The arguments that consumer habits are changing – from less TV viewing to more games paying, web surfing for shopping and information, social networking so that more

hours are spent in front of non-TV screens - will be ignored. Naturally this applies to satellite broadcast and cable channels also. So the realisation that people are getting public service elements, like news, from the web will not figure in the argument.

- Replacing equipment twice – which is necessary to introduce HDTV soon after digital television (DTV) with standard definition (SD) replaces analogue – imposes too much cost for too little benefit, of simply the marginal benefit of a clearer picture. Also, market rejection problems may arise with two transitions close enough to overlap – they will cause confusion and a consumer backlash
- With new channels for media, any public acceptance of the "broadcaster push" model is declining - generally HDTV appears as an improvement coming too late to be a "must have" technology – (eg advanced 35 mm film or AM Stereo)
- In a condition of a strong public demand for HDTV, there may not be enough spectrum available in the VHF/UHF bands for simultaneous transmission of the same programming in both DTV and HDTV formats (now being done for analogue TV and DTV). There may not even be enough VHF/UHF spectrum to accommodate the existing programmes after a future switchover to HDTV.

Hypotheses

The battleground is purely political: it is not about whether there are economic benefits in unlicensed spectrum but over whether spectrum should be 'given' to broadcasters so that HDTV can be delivered via digital terrestrial, on the grounds that otherwise its viewers will be 'deprived' in some way. This is where the battles will be fought, because it is where governments are sensitive as television viewers are voters. Such a strategy may fail as it is illogical – a new and expensive technology and the customer base will not spend money directly.

So is a purely a political decision illogical? Could, however, this be positive for reasons of special interests that give balance between social needs and the market – even if it is a political decision, is it perhaps a socially responsible decision?

Generally the EU TV and media markets will become slowly more complex with more players, some touting new technologies that may or may not be allowed to enter and take off. The release of spectrum opens new battles – between those who want to offer 'standard digital' services and those who want to offer HDTV, and IPTV over multiple over-the-air carriers including those for mobile from Qualcom, Korea and the like.

However the mobile market could well suffer in terms of developments, new entrants, competition, new services including Internet access, reasonable and lower pricing, etc.

Leverage or tipping points

- Pressures on government (Member State and EU) for other allocation strategies
- Public debate over the use of spectrum

The scenario unfolds

Media declare that they need terrestrial HDTV bandwidth as otherwise terrestrial TV viewers will be deprived compared to satellite and CATV who already have it. Moreover they want the spectrum given free, as they will have to spend invest heavily in new technology and its deployment and so will have no funds for licences.

With their leverage, Member State (MS) governments broadly accept what the broadcasters want. Little spectrum is made available for other usages, and most of that is for government and its public services. Managed allocation is the reality across the EU, with some different conditions in each EU MS, eg for DAB radio.

In return, the incumbent TV/radio broadcasters promise much public service broadcasting, claiming to be its guardians. However the customer base do not expect that any switch to digital technology should cost them anything – they do not see why they should pay for an industry technology upgrade and are quite happy to stay as they are. Moreover, the outcome for the viewer in enhanced quality and services is unlikely to be convincing to the viewer base, and the major broadcast corporations already suspect this, whatever their claims. But this is irrelevant, as the battle rages at a government level in each MS. It is here that the real struggle occurs, because it is where governments are sensitive – TV viewers are voters.

The MS governments see the short term benefits to them in a communications channel to the voters which they can influence or partially control, through their existing relationships with the largest media players, which politicians do not wish to upset. Although cooperation between EU telcos and broadcasters might be the best path towards spectrum allocation, in fact there is strong confrontation. Discussion in the global fora, such the International Broadcast Union, as well as the European Broadcast Union and the ITU (with its RCC06 Plan for use of the whole VHF/ UHF spectrum) only exacerbates the difference of opinions. The broadcasters have the EU politicians on their side so will not give up the digital spectrum dividend and its profits to anything other than terrestrial broadcast.

The EU's internal market structure for the traditional terrestrial broadcaster is reinforced by this approach – as are their links into the political centres of power. A fortune is to be spent on the new technology and rolling it out across the EU, taking at least a decade to reach all corners of all MS. However as a standard is agreed and applied early for all details for HDTV, the EU TV technology soon tends to lag the rest of the world.

New technology directions in mobile and other usages of spectrum are largely absent as research into new 4G mobile and mobile media delivery platforms takes place outside the EU, as that is where the markets lie. Technology developments in TV and radio also, as well as mobile and novel radio technologies, are all happening outside the EU. In 2012, Asia sets up its three connected *AMTRI* centres (Advanced Mobile Technical Research Institute) in Beijing, Seoul and Tokyo.

European suppliers such as Nokia, Sony-Ericsson, with the leading content providers and telecoms infrastructure providers migrate there in their R&D entirety to be with the many small software and creative content companies that comprise the key economic clusters globally, all sited within a few kilometres of each AMTRI.

As Web TV takes off outside the EU, its presence is soon felt inside, penetrating easily via xDSL links to challenge terrestrial media broadcasts. In these circumstances, by 2015, the new TV device that dominates Asia with its broadband radio access technologies is the web-TV (abbreviated to the strange name "*Wet-V*" in China and Japan) which also sells well all over the EU. The Wet-V also brings the first 3D TV services and devices, based on Logie Baird's 3D concepts from the late 1920s, as well as "DoD" – definition on demand – with variable resolution by device.

Consequently we see missed opportunities in the EU with nearly all new TV and media technology concepts emerging from outside the EU. In Asia and the USA, R&D continues for new media technology, especially mobile media with mobile-web based forms for interactive and broadcast entertainment, business TV and educational courses, with immersion technology, etc.

This applies equally to the content programming side. EU and US content players increasingly focus on the Asian market and migrate operations and production facilities there, as that is where new content is being creating for the new technologies. India appears alongside China and Japan as a centre of content production, especially entertainment – and a new format appears as 'Bollywood' productions for the cinema change into a new content industry for the web, popularly called 'BollyWeb', although it is centred in Bangalore, not

Mumbai. Via the web, the new Asian programming slowly becomes all the rage in the EU beyond 2016.

Mobile technology in the EU largely stagnates. There is no real progress beyond 2.5G levels of service by 2020. No significant moves are made off the 3G cellular path, carrying 2.5G types of services, as the service prices remain high and rich media content does not really take off. Despite a flowering outside the EU following rollout of novel broadband mobile technologies and with them, mobile media such services remain far too expensive for most citizens. EU 3G penetration increases in many urban centres, with smaller cell sizes for denser call coverage as the technology becomes a platform for over 50% of users. In parallel, wireless LAN access within and around buildings increases with WiFi connected to fibre backhaul.

Hence, outside the EU, WiMax and radical new technologies provide low-cost broadband radio access over ranges up to 10 kilometres. But in Europe, mobile services never really move outside the envelope of voice and SMS, the 2.5G model. The faster data services are deliberately maintained at price levels too expensive for web-surfing, file download or streaming, etc, as 3G UMTS HSD/UPA networks cannot handle the demand for many wideband 2Mbps streams simultaneously at acceptable cost, as they are inherently too expensive and unreliable, especially with IMS. Note that the digital dividend is not used to close the 'digital divide' in this scenario.

The lack of mobile broadband access has a knock on effect on Internet access. Internet access in its full broadband form is restricted for most MS until the fixed line fibre networks are rolled out, by CATV or as the NGNs by telcos, but this is mostly in the urban centres, although fttc (fibre to the curb) soon spreads to the closer suburbs, and xDSL is made to look obsolete, to sell the fibre offerings despite their higher pricing. Rural areas have little or no broadband coverage and Universal Service edicts will not effectively be applied as most MS cannot afford to support such initiatives and rely on the market to provide whatever access they may, by default through fixed lines – be it fibre or xDSL.

In these circumstances, consumers focus on a new segment of personal media recording for all types of media and information based the new MP-6 technology from Asia. These recording devices form the substitute for personal TV and are used to gather content off the web and display it, perhaps via a home media centre or intermediate device such as an STB with added Internet interfaces. This follows the user perception of seeing different media streams increasingly as a single pool of content which should be interchangeable. They are only frustrated by different DRM barriers, despite early initiatives such as Coral to integrate different DRM schemes. HDTV can be captured off-air as one stream, but a special device may be needed, as in some MS, decoders may be allowed, to make it more difficult to obtain free use, despite the original arguments of social value for all. Instead of public acceptance and DRM compliance, there is widespread use of illegal multiple DRM cracking software, downloaded for free from 'DR freedom' websites such as '*Pirates of the Cyberspacean'* and '*Notfairplay*'. This is used to build up personal libraries which are increasingly swapped as peer-to-peer content via the Internet, building an underground alternative TV and audio content cultural movement.

Local TV services, personal TV via public service platforms and special interest programming have little access and do not flower, which drives the underground TV cultural movement, linked via its personal recording media and the Web. Alternative mobile uses for radio technologies are also stifled – including the integrated emergency networks, increasingly needed for the growing rate of climate change catastrophes, as well as health and care networks and sensor array technology, in use in other world markets for many applications.

Thus the structure of the EU converged media/telecoms industry up to 2020 stays fairly unchanged from today, with six main segments:

- Terrestrial broadcasters - largely a slow consolidation of the major EU incumbents, surrounded by their smaller content production companies, in a gradually fossilising and dying ecosystem, who produce much of their own content for each MS language
- The CATV operators, and also the satellite TV operators – both may have terrestrial broadcaster links or links to each other (eg B-Sky-B, Virgin Media) either through cross shareholdings and/or content provision and diffusion agreements. Increasingly they present a triple or quadruple play strategy. As a part of this, they may offer web-TV as well as the conventional programming. Their spread is slow but sure against the terrestrial broadcasters. Sometimes they link with, or are owned by a telco, to offer interactive fixed broadband access in the case of the satellite operators, and /or mobile communications, for both CATV and satellite quadruple play. Increasingly incursions from the US (eg private equity) may change their shareholding – but not their base strategy.
- The EU telcos, mainly the larger incumbents, slowly pushing into media for content for their fibre networks, as they progressively roll out broadband into the home and office, with side deals with other types of player for fixed broadband and mobile narrowband access. As ever, their dilemma remains one of trying to decide whether to be a media company, through acquisitions and production deals with content providers, or else to stay as a network operator of bit-pipes, with effective separation of services from network infrastructures.
- Content providers – divided into resellers of content produced from outside the EU, and a heroic but withering EU industry, producing high quality material, but not at the same level technically as those outside.
- Suppliers of TV technology, for terrestrial broadcast, satellite and CATV with STBs – these are increasingly larger Asian suppliers as the EU is a small, less developed branch of a global market, easily catered for in cut-down technology
- Suppliers of Web-TV technology, largely from outside the EU, including personal recording devices from MP-3 players to MP-4 devices for HDTV and any other new formats

In looking at this scenario as whole, the only 'strength' is perhaps in the maintenance of the spectrum position for the terrestrial TV broadcasters. Even this is precarious in real terms as web-based services and content take more viewer time and market share. The case for HDTV as being of overwhelming benefit does not hold up, and newer standards and novel TV technologies would make any early version obsolete by 2020. Special minority interests are mostly shut out so the social dimension is poor. Development of mobile services in the newer bands is unlikely, leaving the EU to pursue a future based on expensive 3G technology which brings a steady but sure decline in Europe's fortunes. Mobile is unable to provide the bandwidth to the number of consumers who would benefit from it, unless other spectrum areas are opened and/or new spectrum technologies (CR and SDR for adaptive spectrum usage, with direct spread spectrum, etc) can be harnessed for re-using the little bandwidth available. But this technology is only being developed, albeit it fairly slowly, in Asian markets for Asian customers. Investment tends to be drawn to regions outside the EU, both for services operation and for new technology. And innovative potential in mobile and TV technologies tends to migrate elsewhere than the EU.

Moreover in this scenario, the one-time opportunity to close the 'digital divide' using the digital dividend is ignored.

A final comment based on UK Channel 4's CEO Andy Duncan's scepticism:

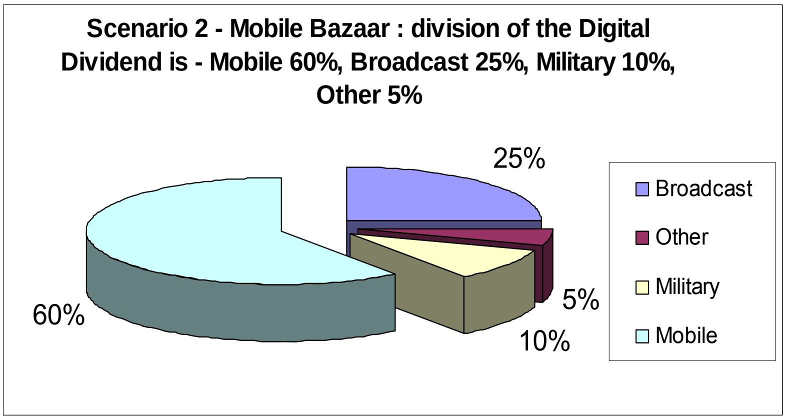
"It's really hard to see that by even 2020 HDTV is going to be in the majority of UK homes. So it is silly to start broadcasting HDTV in these bands if they could not accommodate a fully developed HDTV service later on. For these reasons, it could be unwise to reserve or allocate any UHF spectrum for HDTV until completion of the Digital Switchover, when

broadcasters will have a clearer view of whether their resources and their audience will justify a further transition to HDTV. Increasing the interval between the DTV and HDTV transitions will also reduce confusion and resentment about premature replacement of equipment. UNCLEAR whether HDTV can completely displace DTV, or must develop along-side DTV as a sub-genre like mobile TV, or if demand for HDTV will be too limited to support the cost of diffusion, as with the videodisk. When the level of take-up can be more accurately foreseen, then it will be possible to determine whether terrestrial radio transmission is appropriate. If the audience is limited, then cable, FTTC/ FTTH and satellite may be sufficient delivery options."

Scenario 2 - Mobile Bazaar

Theme: The most significant proportion of the spectrum is released via a licensed spectrum regime for advanced cellular mobile communications services. This stimulates a lively mobile market with many players across Europe. The proportions of spectrum allocation for each allocation type are shown below:

Figure 3.2. Spectrum allocation proportions for scenario 2



Key drivers

- Thriving European market for mobile services of all kinds
- Demands from MS governments for new auction fees, often driven by size of national deficits as a percentage of GDP
- Demand for spectrum from established cellular players
- Demand for spectrum from new players, enticed by possibility of a ticket to new entry to the European market
- The potential promise of new services especially mobile TV

Assumptions

- The telecoms industry as whole realises that UHF is a radio spectrum band that is extremely valuable, more so than existing bands for some circumstances, due to its excellent propagation characteristics making it particularly suitable for mobile applications. It lobbies hard for favourable allocation.
- The EC tries to set up agreed bands for mobile re-use and for a smaller digital broadcast portion plus some other applications. This agreement is endorsed to varying degree by many MS at EU level but not all. In those MS that endorse it, licences are allotted for the most part for mobile re-use of the released spectrum, usually via mobile auctions.
- By using a set of designated bands for each application and service type roaming and broadcast programming harmony is assured, with co-operation of the ITU / RRC, EBU, etc.
- The EU-wide agreements made - but only approximately kept to - are: 60% cellular mobile, 25% broadcast with other favoured with some 5% of the available spectrum and the military conserving the rest, around 10%.

- Individual MS governments declare their own specific processes for spectrum allocation, each according to their own national agendas despite the EU issuing allocation guidelines (conditions for numbers of licences and possible fee levels, policies for encouragement of new entrants, etc). But these EU guidelines are incompletely followed, or ignored, by MS. It results in an EU patchwork of operators and roll-out conditions.
- MS allocation policies vary widely, from purely market to command and control management with some mixtures of both. Auctions are the most common mobile spectrum allocation method, with fees being claimed by each country's government for their own purposes, often nothing to do with communications and supporting their social benefits. As the auctions are on a MS national basis, so there will be major variations in numbers of licences, their lifetimes, fees, dates of allocations, conditions of roll-out, etc.

Assertions

- Strong attempts are made by MNOs to build EU-wide markets using new spectrum in each MS as the ticket to market entry to new geographic markets – and the extension to new geographic markets tends to reduce the digital divide.
- Expansion in new services accompanies this geographic expansion.
- The spectrum market quickly separates in to 2 segments – with the traditional established services (2G, 2.5G and 3G mobile services, as well as terrestrial radio and TV broadcast) being at the centre of the trading markets for the frequencies that are most highly sought after. The second part of the market covers the less attractive frequencies, with much less or no trading.
- The EC, with the main international industry organisations (ITU, RBU, CEPT etc), fails to get really complete agreement from MS on frequencies and usages of the new spectrum other than that mobile usages will dominate. What it gets are agreements on key bands – such as 490 to 550 MHz and 570 to 630MHz as a baseline agreement.
- Many MS follow an auction strategy and either sell far too expensively or fail to get any bids as no interest from local (new entrant/ small existing) players who will not bid as expect others with deep pockets to bid higher
- Mobile industry attracted by the Digital Dividend as it can be used to extend the coverage of 3G/UMTS services as a lower cost infrastructure with UMTS-500 (and also to large areas of low population density). They will also promote the concept of providing TV to mobiles (eg via DVB-H)[15] for rapid introduction of new and innovative Mobile TV services in broadcast frequency bands as the key aim.

Hypotheses

- To enlarge the proportion of spectrum allocated for mobile, the mobile industry notes that mobile TV also needs to be considered with terrestrial broadcasting as it does not yet have a portion of the spectrum. It is put forward that this should be irrespective of how mobile TV is provided and independent of the transmission mechanism, be it delivered over a cellular network or directly over new broadcast channels opened by the digital dividend for mobile TV such as DVB-H, etc

Leverage or tipping points

- The amount of spectrum won by new entrants, for new services
- Allocation of spectrum for specific applications (eg cellular mobile), rather than distribution as technology and application neutral bands
- Uses of auctions – the market approach – in preference to managed allocation/beauty contests
- Auction structuring – for highest bidder takes all

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[15] For example, Open Letter from the Joint Mobile TV Group, UMTS Forum and GSMA to the RRC-06, 5 June 2006: 'The mobile industry calls for the consideration of necessary spectrum to enable the development of mobile TV services'. The UMTS Forum and the GSM Association look forward to seeing agreements that will take the appropriate measures by the Regional Radiocommunication Conference.

The scenario unfolds

Mobile players press for the Digital Dividend to be harmonised across Europe for various usages. For a cost efficient extension of rural coverage and affordable infrastructure, as part of the allocations for the ITU standard UMTS classification IMT-2000/UMTS, they seek EU harmonisation, of new bands with a minimum of 2x30 MHz in the lower part of the UHF band – preferably below 600 MHz. This would provide 3G cellular services in currently uncovered areas in Europe at affordable prices so 3G take-up might increase from its meagre 5% in some MS. They also seek endorsement internationally, that is in the WRC-07 global radio conference, for mobile bands in the 470-862 MHz band in the EU (ITU Region 1). One of the great hopes is mobile TV. The Commission then begins to examine it: the RSPG requests CEPT studies for suitable technical and policy strategies.

The aims of MS governments and established MNOs coincide and are reconciled through the spectrum process – governments raise funds for their treasuries and MNOs, acquire the spectrum they need.

However, the EC, with the ITU, fails to get effective universal accord on spectrum usages by band, only imprecise agreements. A first problem is not so much that the military and public services hang on to specific frequency bands but that these are, more often than not, quite different in each MS.

The single exception for unanimous agreement is an emergency services band around 700 MHz for a new high capacity European mobile radio first responder network ('EUFREBORN' - EU first responders' broadband operations radio network) for multi-MS, multi-service operations for climatic catastrophes and cross-border terrorist attacks etc. It covers the EU from Riga to Rome and is designed to carry video, images, voice, data and tracking location over multiple dynamically adaptive 1- 3Mbps channels.

The majority of MS pushed by the EC choose to go for the pure 'market solution' of selling off a restricted number of licences (some with twenty year validity, some for ten) which are tradable and initially let via auctions. But it is the auctions in each MS that are the key turning point for the future EU development in mobile:

- The amount of spectrum offered in each MS, varies somewhat across the 350 MHz available, as a few MS mix managed command and control awards for some usages with market allocation for mobile. Certain of the key bands (which are best for the economics of mobile networks) are only available in a patchwork pattern across some groups of MS across the EU. Moreover, the EC cannot obtain harmonised agreement from the MS after this has occurred. For instance, a very few countries refuse to offer more than around 100MHz for mobile pushed both by the broadcasters through their links to government into a managed allocation.
- Some favour the mature markets as the best investments, such as the Nordics, the UK and Germany as being the first likely to take up advanced services, if the prices can be bought down. But in some (eg UK) the bands offered may not be as attractive as in other MS and may be far less on offer overall. However the new large markets (eg Poland) or those with some room for higher penetration (eg Spain, Bulgaria, Romania, and even France) turn out to be the hottest battle grounds.
- The spectrum market quickly separates in to two segments – first those with frequencies most suitable for enhanced performance of traditional established services (2G, 2.5G and 3G mobile services) being at the centre of the auction interest and also for secondary trading. The second part of the market covers the less attractive frequencies, with lower prices, some unsold lots and much less or no secondary trading.
- Special purpose vehicles (SPVs) appear in some member states, which are holding companies designed specifically to buy spectrum for trading, wherever the covenants on roll-out are relaxed, and so effectively secondary trading is greatly encouraged. In these MS – known as the 'tulip markets' in the industry - prices tend to be higher, as local

interests build consortia, often with local funding. Overall investment in the mobile industry tends to increase strongly, with the SPVs also attracting finance from private equity groups, particularly more aggressive players from the USA who have already tasted the European telecoms markets.

Nevertheless, the auction designs are considered to be successful for the MS governments and MNOs – governments raise funds for their treasuries and MNOs obtain much of the spectrum they were hoping for. Although MNOs spend significant sums on licences, the amounts are not crippling as they were in the case of 3G, allowing them to spend money on technical development, eg technical variations of existing standards (UMTS 500) and new twists (GPRS-550 and HD/UPDA-600/650) introduce new services and niches such as fast data access for mobile Internet.

Market expansion for the existing players, expected higher penetration numbers leading to stronger revenues and margins, gather pace slowly. Overall, the digital dividend introduces increased competition in mobile cellular. This softens levels of ARPU across all cellular markets. But the digital dividend also means much enlarged markets for some, which compensates those larger MNOs able to restructure their business structure and strategy for lower ARPU in general across a larger subscriber base.

Interestingly, the SPVs drive this competition and ARPU further, especially in the new and accession MS, who have used the new allocations to launch local players against the established MNOs. SPV financing follows the “Eurovision Song Contest syndrome” that nearest neighbours will always vote for local players, even if they come from the next border country, in preference to a more distant player. In this way, the SPVs attract large amounts of local finance, changing the balance of the local and adjacent markets. They then sell off the spectrum in smaller segments, where allowed, to increase profits. As a result, many small local players are seeded, some viable, some not.

Thus initially after 2012 we see significant market entry with new players which results in a number of effects. The market is dynamic and there is immediate downward price pressure on existing services as new players compete with established operators for market share. There is also stimulus to develop and roll out new, advanced services into new geographical areas. The desire for mobile broadband especially strong in the rural areas of the newer Member States – but affordability is an issue sometimes. Thus, the market is developing gradually and new services take off more slowly than anticipated. The operators who have overstretched themselves are unable to survive and this leads to a significant consolidation in the market.

Additional pressure comes in the form of third parties introducing Skype-type voice services via Internet access, paid for by advertising or web browsing in some way. The downward pressure on prices brings further consolidation meaning that only those with the lowest cost models are able to thrive. Thus operators look for new streams of revenues in content and transaction services, using the broadband capability at low cost.

From 2009/2010 on Mobile TV is gradually launched, initially with great fanfare. Supported and proposed by the EC’s RSPG in its Opinion on Multimedia Services, a patchwork of adequate spectrum with some differing bands is made available for two multiplexed bands per MS. It is termed ‘Mobile Broadcasting’ and the whole subject is promoted by the cellular industry as an important new service that will foster growth and innovation in Europe. Mobile TV is introduced within the existing ITU RRC-06 plan but the harmonization of a UHF sub-band for mobile broadcast services, needed to improve terminal performances, reduce network costs and improve compatibility with fixed reception broadcasting and increase spectral efficiency, is only partially adopted across the MS.

On the broadcast side, terrestrial TV and radio stays much the same, with some essays into efficient bandwidth usage for HDTV on a trials basis, using the 20% of the dividend for a mixture of DTT standard and HDTV in many MS. One surprise is the licensing by a few MS of bands for satellite usage at these lower frequencies, following demands form local consortia. The lower frequencies allow both the geostationary, and new LEO satellite schemes, to propose low power, more focused, satellite transponders for the space segment and much smaller receiving antennae on the outside of a customer dwelling. In fact the whole system is cheaper than its conventional rivals higher up the spectrum, in the GHz ranges.

The initial focus by most players is on producing higher penetration numbers for the existing markets and to rollout-quickly in the new geographic markets. As the market develops the digital dividend produces fierce competition from new entrants and cost competition with the lower infrastructure costs.

The outcome for Europe is that the lower priced infrastructures make conventional services more affordable, market saturation is reached more quickly than without them in the new MS. This does increase employment in the MNOs both for operations and for network installation. Employment in associated service industries such as logistics and retail distribution of handsets also increases.

Also the forcing of broadcast into a narrower spectrum envelope does focus corresponding R&D efforts on better use of what is available and also drives development of a new generation of low-cost satellite-based systems able to exploit the bandwidth available.

Employment and revenues in the content production industries, including for mobile advertising climb, but are less changed than expected, possible an extra 5% or less in revenues and employed numbers.

3.3 Initial conditions

These are the input conditions for all scenarios.

Here we examine the outlook for the next five years to see if there are any discontinuities that would radically change their impacts.

- Political – choppy stability with security fears, and disillusionment with ‘united states of Europe’, or a federal Europe, but the EU continues to host the largest global group with a medium/high level of prosperity, moreover one which is expanding by accession and building greater stability across more of the world.

- Financial – generally more optimistic than pessimistic but major variations in outlook and status by MS eg France and Italy v Scandinavia, and fears of inflation in EU due to world energy and commodity prices. High risks of sharp changes due to housing market inflation, derivatives usage and hedge fund collapses.

- Economy type – consumerist – dependent on consumer disposable income and increasing dependence on consumer wealth in EU economies with disposable income being a major part of the economic drive and maintaining growth. An increasing proportion of consumer wealth is tied up in property – a potentially unstable situation.

- Social – inclusion problems – varies by MS, and goes with failing services for health, social and elderly care. General slow deterioration in social conditions, in terms of violent crime, rising prison population, and personal security becoming generally worse across EU.

- Family structure – slowly changing towards more single parent families and also growth in single occupiers of a home.

- Work-life balance – increasing wish to have more free time, and to assert self through accomplishments, both in and outside employment. Increasing convergence of values across Europe with EU enlargement.

- Energy – prices generally increasing at high rates while security of supply is far more volatile than the previous decade.

- Environment – accelerating warming with effects on weather, agriculture, settlements, recurrence of natural disasters and their multiple effects on the economy from health, energy costs, building costs to insurance rates and insurance failures. Increasing problems of pollution of all forms – industrial and household low-toxic waste, greenhouse gas emissions, toxic chemical spills, nuclear materials leakages, etc with rising health issues.

- Employment – problems at extremities – youth employment and post-50 age-groups. This is generally a major problem for EU economies with high protection for those in work, high employment overheads and inability to create and attract new enterprises.

- State support - Pensions, social security, health systems failing.

- Demography – aging population, EU slowing population growth, birth rate falling, immigration rising, EU absolute levels rising by accession.

- Commodities – world prices rising fast (wheat, coffee, maize, cocoa, etc as well as raw materials, metals, etc).

- Oil and gas – world prices rising and staying historically high.

- Physical infrastructure – transport, water, energy distribution (electricity, oil, gas) - highly variable across EU dependent on recent history and political agendas followed for investment in infrastructures' renewal.

- Technology acceptance – rejection of intrusive technology with growing privacy concerns across EU. Access technologies increasing shown in Internet growth expanding in new accession countries, WiFi hotspots expanding over Europe and DSL spreads.

4. Estimating the impacts of alternative spectrum uses

4.1 The importance of the scenarios in our final results

Our main findings are based on examination of the scenarios to interpret the potential outcomes of the various spectrum policies. As we have already indicated, limitations in the availability and quality of data does limit accuracy when extrapolating future time series, but this qualification applies to both scenarios. Scenarios are by nature *approximations of reality* – they simplify and extend the strongest features beyond what may happen to ensure that each scenario paints a picture that is vivid, clear and well distinguished and contrasts with other scenarios. Any limitations in baseline estimates can be taken as being equal for all scenarios. As long as they are reasonable, they give a suitable basis on which to compare scenarios, because scenarios and their differences are the major focus of the debate.

Thus, the scenarios set the scene for the quantitative findings in that they define the forms and level of behaviour and competition in each market and specifically the economic benefits between markets. Until now, such estimates have largely been evaluated for the digital dividend only in terms of consumer and producer surplus.[16] Levels of competition really set the scope and form of market behaviour that spectrum allocation unleashes in that it decides:

- The entry of new players who raise the degree of competition in the market; they depend on spectrum being available to operate services, be they media or mobile
- Pricing of services, through the initial fixed costs of spectrum, be it large, 'reasonable', or free as the spectrum allocation affects the costs of the infrastructure for each type of application – for instance for a broadband wireless services market

Our analysis below presents our findings but also serves as a worked example of the whole methodology.

4.2 Quantitative results

The Micro-economic level parameters can be viewed as what is happening to the consumer and the citizen or an individual company. We used common assumptions across the scenarios for shaping the micro-economic parameters' base cases (ie the status quo in spectrum allocation) before applying the spectrum impacts for each scenario. The rationale used is as follows:

- *Micro-1 Mobile ARPU, US$, EU-27* - although release of spectrum under any scenario has some affects on usage as pricing becomes better value, it soon saturates. Increasing ARPU stabilises under forces of competition and saturation. With mobile VoIP, prices descend fast, despite far greater usage, for perhaps 5 to 10 extra applications by 2020 (music, news, voice, some video calls, business data, shopping) using mobile Internet.
- *Micro-2 TV spend as %age of total household spend on e-comms* - Goes up with some spend for set top box (STB) for DTV and new screens/ VCR, also satellite and CATV then shrinks under less use & competition - %age declines as spend finishes and competition (eg IPTV) as well as non- broadcast TV operators reduce costs to household, and no new TV spend items appear.

[16] See for example, Thomas W. Hazlett, Jurgen Muller and Roberto Munoz, 'The social value of TV band spectrum in European countries', *info*, 2006, Vol 8 No 2, pp 62-73.

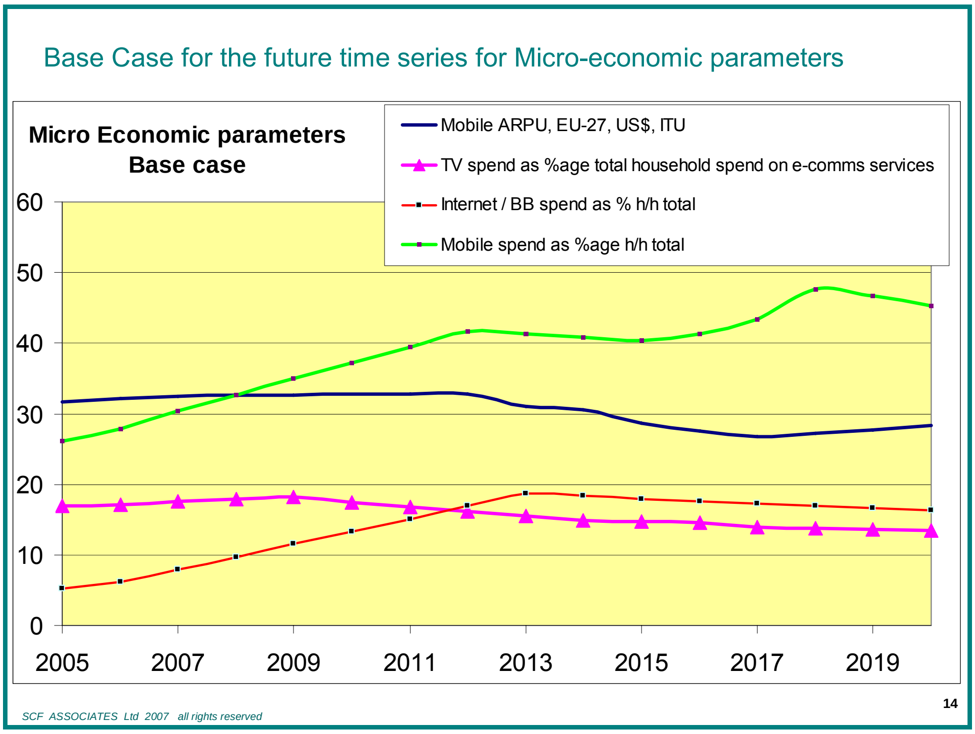
- *Micro-3 Internet/BB spend as % age of total household spend on e-comms* - Goes up fast especially with downloads, IPTV etc, then later - after 2012 - saturates, as mobile Internet (spend in ARPU) and competition - with flat pricing - reduces overall spend %age and with IPTV starts to replace terrestrial TV. So with arrival of mobile internet, beyond 2012/2014, Internet & broadband spend switches into mobile percentage of total spend on e-comms and the former's prices also come down with competition.
- *Micro-4 Mobile spend as % age of total household spend on e-comms* - Disposable income rises but mobile prices stagnate and total spend as %age of household spend decreases faster but mobile stays constant as it replaces more of fixed in total percentage, gives mobile internet access and after 2015 take-up of new services may take off.

The projections are formed using two inputs:

1. The time series over the range 2000 -2004 which had reasonable data in terms of quality for all the four micro-economic parameters and so provided the absolute level, typical behaviour, and thus a start series for forward linear trajectories
2. The influences of the above trends, with their impacts on what might otherwise have been a simple linear growth development. The future parameter values are then based on the logic of the relevant market behaviour and events described for each parameter above.

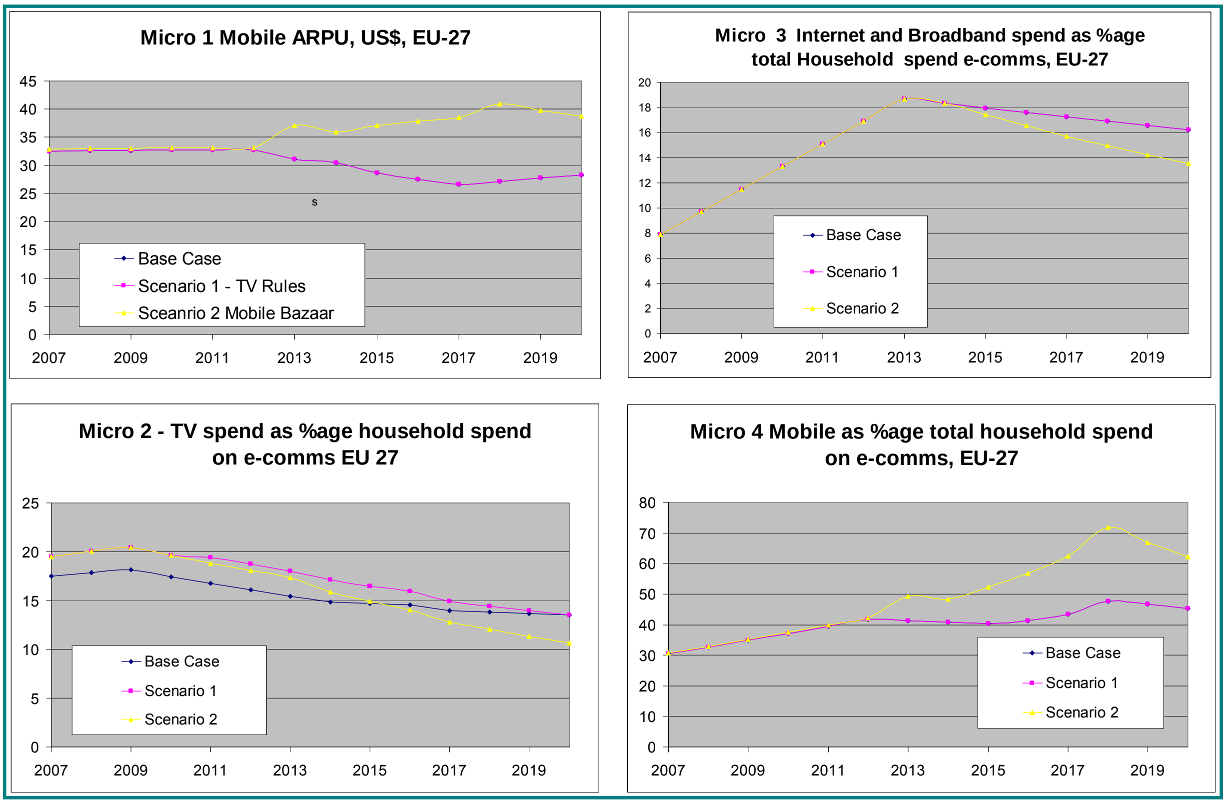
The resultant projections from these inputs can be represented graphically as shown below with the Y-axis referring to each parameter unit as given in the legend for the 4 parameters:

Figure 4.1 Base cases for Micro-economic parameters



We can then apply the scenarios to the micro economic parameters, shown in the figure below in a setting simulating the expected parameter behaviour from the scenarios against baseline going forward to 2020. These set the whole estimation process in motion for the two scenarios across the various levels of economic aggregation. They have the shaping functions included, which drive the overall trajectory of each parameter.

Figure 4.2 Micro-economic parameters under scenario conditions



The profiles above for micro-economic parameter 1 ("Micro-1") describe mobile ARPU as increasing for Scenario 2 after 2012 as the switchover favours better value for money and new services over the extra capacity. However after 2017, descending mobile ARPU appears in the Mobile Market scenario as ordinary calls are competing against lower cost VoIP. The exact date when this happens is debatable. But we have assumed mobile VoIP may take some years to become generally accepted for voice quality reasons, although this could be pessimistic. This mobile situation drives up usage and mobile spend – so we would expect the Broadcast Media Rules Scenario 1 to show lower mobile usage. As the value of mobile is better with lower cost, it is used more, especially for more new services, driving up proportional household spend (Micro-2) as it provides Internet access, after 2017 percentage of household spend on Internet and broadband (Micro-3) also declines as mobile Internet and VoIP becomes widespread. Thus proportional spend on other services such as TV (Micro 2) would tend to go down in Scenario 2, as does broadband Internet spend as Internet access via mobile becomes more important in scenario 2 with extra spectrum for mobile Internet.

From the past time series for both Meso and Macro we must also produce the linking mechanisms for forward projection as outlined in Chapter 2 on the methodology, (see particularly Figure 2.6). We generate the cross correlation coefficients[17] between every Meso parameter and each Micro parameter to form a matrix of coefficients. This enables us to understand which Micro-economic parameters are well coupled with the Meso-economic parameters. Cross correlation coefficients as found between the time series for Micro and Meso-economic parameters time series displayed strong links in many cases – highlighted in the matrix as shown below. One problem with such results is the very strong correlation in

[17] The formula for cross correlation coefficients used $\rho = (1/N \ \Sigma \ (mi-mi') \times (me-me')\ )/\ \sigma\iota.\sigma\varepsilon$, is the standard algorithm, where mi' and me' are the mean values of each Micro and Meso parameter time series, while $\sigma\iota.\sigma\varepsilon$ represents the product of the standard deviations of the micro and meso past time series.

some cases. This should be taken as indicative rather than literally, because, as previously emphasised, the sample range is very short for highly robust results:

Figure 4.3. Cross correlation between Micro and Meso-economic time series

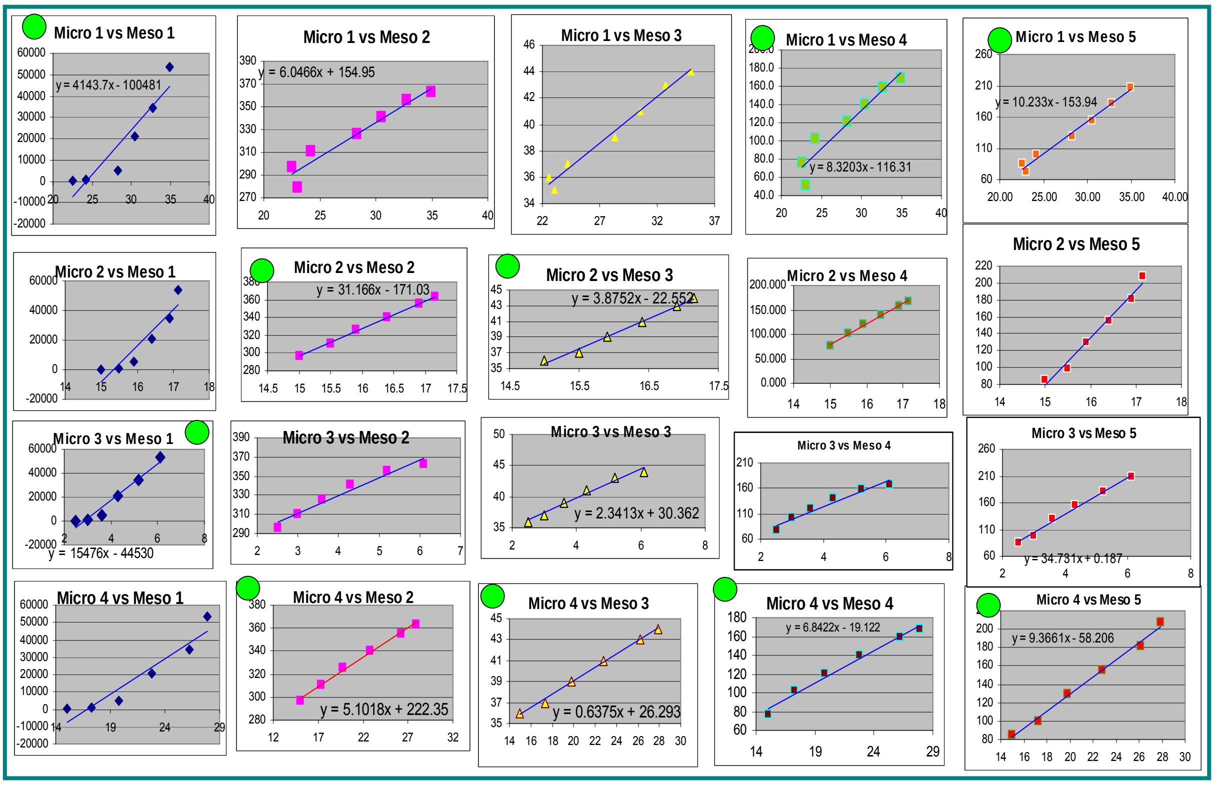
MICRO/MESO *Cross correlation coefficients*	Meso - 1 WiFi hotspots	Meso - 2 TVs Millions	Meso - 3 TV revenues	Meso - 4 W. Europe Handsets	Meso - 5 mobile Revenue
Micro-1 Mobile ARPU	0.902	0.961	0.960	0.956	0.862
Micro-2 TV spend as % Household spend	0.938	0.999	0.996	0.998	0.890
Microl-3 Internet/BB spend as % H/H spend	0.980	0.983	0.988	0.974	0.641
Micro-4 Mobile spend as % H/H spend	0.955	0.997	0.998	0.992	0.894

reasonable logical link and correlation

Chosen for future Meso series generation on criteria of most logical link, rather than pure Cross Correlation coefficient value

At least two micro series coefficients are chosen to generate the meso level future series from the micro level future series above. Parameters are chosen on the criteria of the strength of logical link as well as the value of the correlation link (its approach to 1.0). Then from scatter graphs on the past time series, shown below, we can plot simple linear relationships for the future time series for Meso parameters based on the forward projections of the Micro level future time series.

Figure 4.4. Scatter diagrams show correlation between Micro and Meso-economic parameters with regression lines to guide simulation of future behaviour



The scatter charts give an indication of the *form* of the relationship, where there is a strong relationship as given by the correlation coefficients, and what is that relationship as a regression line. Graphs chosen for future extrapolations are also marked by a green circle. Note that the regression line throughout of the simplest type, that of a linear relationship, $y = mx + c$ formula, whose dependent variables are stated in the figure above, for the chosen parameters. As noted, we use certain assumptions for the future time series for Meso-economic parameters for shaping the base cases and then for the adjustments for scenario behaviour of each Meso parameter. The bases cases use the following logic to shape them:

- *Meso-1 EU-27 WiFi hotspots, number* - Strong take-off growth continues to 2014 then still constant but then slowing increase as density of usage reached across most EU-27

- *Meso-2 EU27 Millions of TV receivers* - Increase with sharp increase due to replacement sales 2011- 2015 then saturation around 2016 and STAGNATION. Home TV usage becomes multiple function terminal including Internet access, video conferencing, mobile phone accessory as well as download IPTV display. Laptops used as TVs by many; projection screens from mobiles also replace standard flat screen TVs

- *Meso-3 EU27 TV revenues, € B* - Increase slowly but stagnates as saturation around 2015 with slow decline as TV traditional revenues dispersed to multiple sources and content providers with more peer to peer content, such as YouTube videos

- *Meso-4 EU27 Handset Sales 2002-2011*, *million units* based on W-Europe - Continued increase with slowing with saturation from 2011, as replacement sales on 2-3 year cycle for 500 - 600 million units installed base despite move to new smartphones and then the simplephones from 2012/2014

- *Meso-5 Revenue from mobile communication, US$ billion* - Increasing until impacts of new VoIP mobile felt and then saturation of minutes despite new applications after 2012 and 2015 which maintain minutes but not spend - as mobile Internet access becomes major usage (and includes m-VoIP which decimates plain voice revenues)

We then apply the scenarios to produce differentiated results for each. Key assertions behind the shaping functions used to produce these ‘Future 2’ graphs have the following rationale:

- *Meso-1 WiFi hotspots* – as indication of growth of ICT and Internet uptake - impacts of mobile Internet felt after 2014 so growth slows in scenario 2, as Internet access transfer to mobile

- *Meso-2 TV in use* – Based on impacts of Mobile TV, IPTV over mobile Internet access etc causes an initial hic-cup in TV set sin use and sales in Scenario 2 as there is more bandwidth for Mobile TV services. However this is a temporary blip. Later on, mobile TVs may tend to substitute for conventional TVs in use but total numbers of TV sets in use are still significant and new mobile channels drive TV sales as a screen for display of off-air content as well as on-air

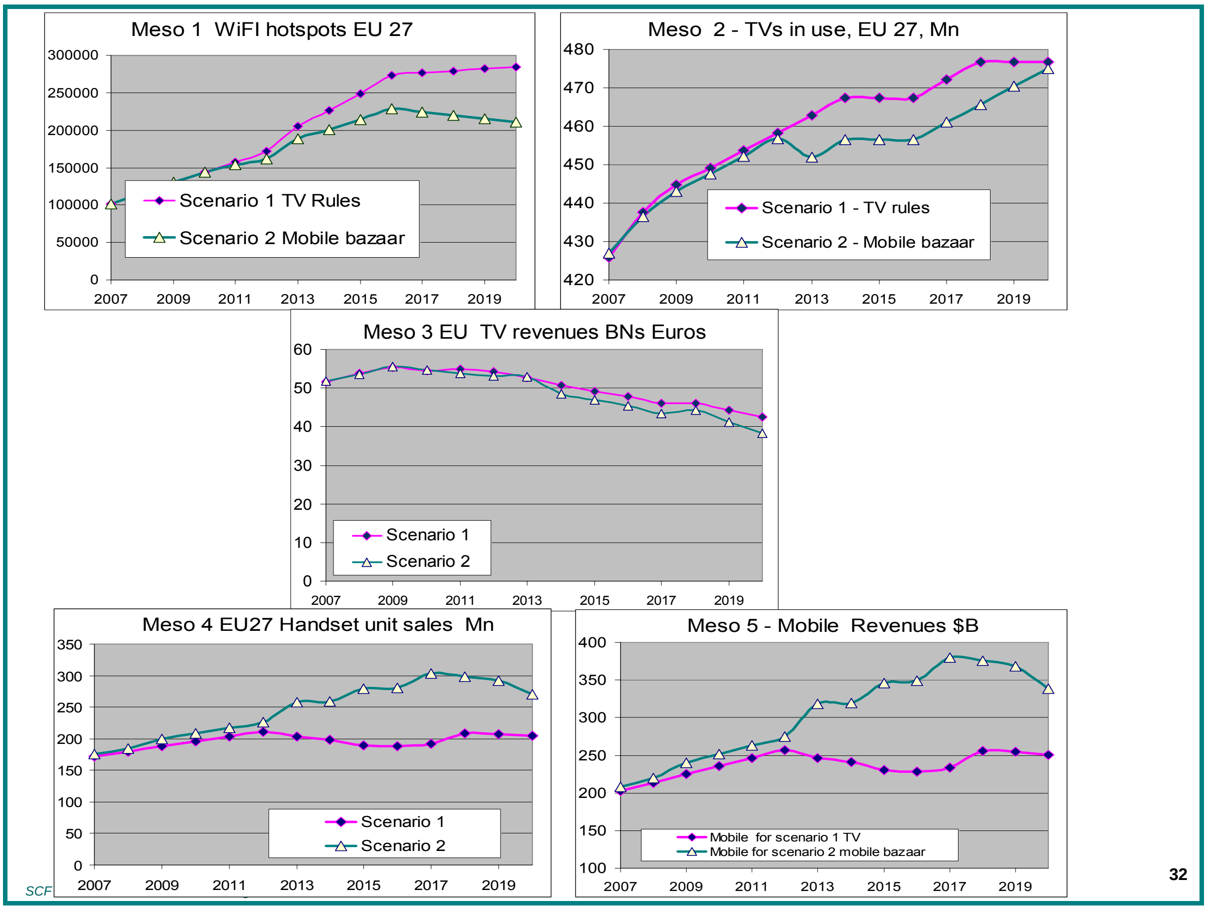
- *Meso-3 TV Revenues* – generally TV revenues for broadcast decline as other channels (CATV, Web TV, Satellite etc) take up demand. However in Scenario 1, more spectrum should allow more broadcast DTV services - and as long as they are taken up, slightly more revenues, so Scenario 1 leads over Scenario 2

- *Meso-4 Handset sales* – availability of Internet access from 2012 tends to increase sales, and useful media/Internet services, declining from 2017, with saturation of the new handset models

- *Meso-5 Mobile revenue* – rise with scenario although unit prices may fall, overall usage increases until VoIP forces prices to decline, after 2015 only maintained via new demand for useful extra services at affordable prices, exploiting data more.

Results for the final future series for the five Meso parameters are shown below:

Figure 4.5. Meso parameters to 2020



We now estimate the macro-economic parameters, using the past series correlated with the historical meso-economic data to produce the following cross correlation coefficients:

Figure 4.6. Cross correlation between Micro and Meso-economic time series

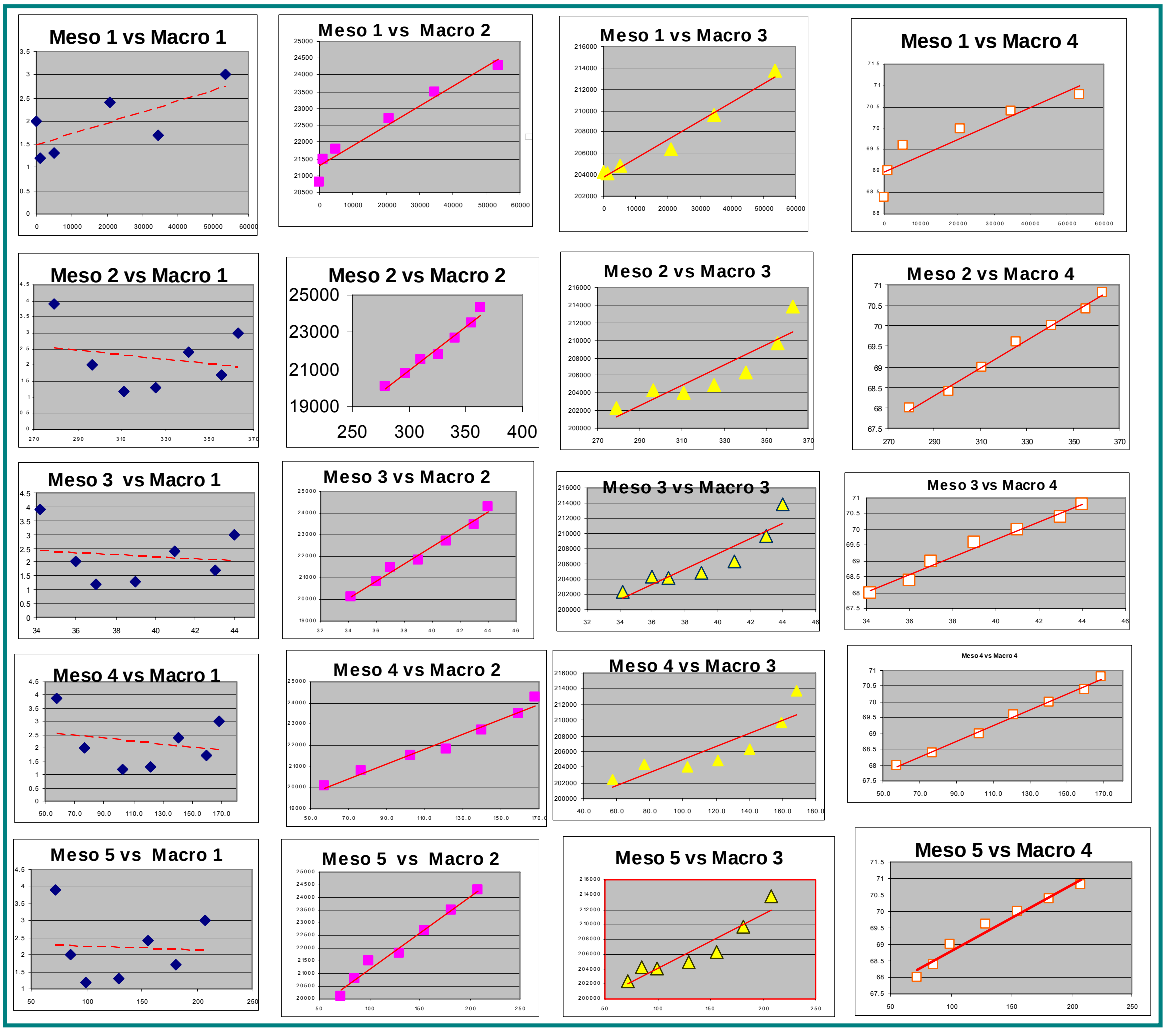
MESO/ MACRO	mE-1 WiFi hotspots	mE-2 TVs Millions	mE-3 TV revenues	mE-4 Handset sales	mE-5 mobile Revenue
MA- 1 GDP growth rate	0.743	0.550	0.597	0.510	0.228
MA-2 GDP/head	0.977	0.984	0.986	0.977	0.910
MA-3 EU employment EU27	0.987	0.885	0.908	0.863	0.854
MA-4 Employment in services as % total employed	0.917	0.996	0.987	0.997	0.906

reasonable logical link and correlation

Chosen for future Macro series generation on criteria of most logical link, rather than pure Cross Correlation coefficient value

This is a much more problematic result. The cross correlation coefficients found between the time series for Meso and Macro-economic parameters display strong links in some cases – but GDP growth is a difficulty. No strong correlation with Meso parameters is shown, except perhaps with WiFi Hotspots, which seems to follow a reasonable train of logic. The regression lines also highlight a similar lack of real relationships between variables, as shown below. This may be explained by the problems of GDP growth being driven by structural problems of producer industries, natural disasters, the price of energy supplies, residential housing inflation and its direct effects on wages, etc, so its time series is erratic.

Figure 4.7. Scatter diagrams show correlation between Macro and Meso-economic parameters with regression lines to guide choices for simulation of future behaviour



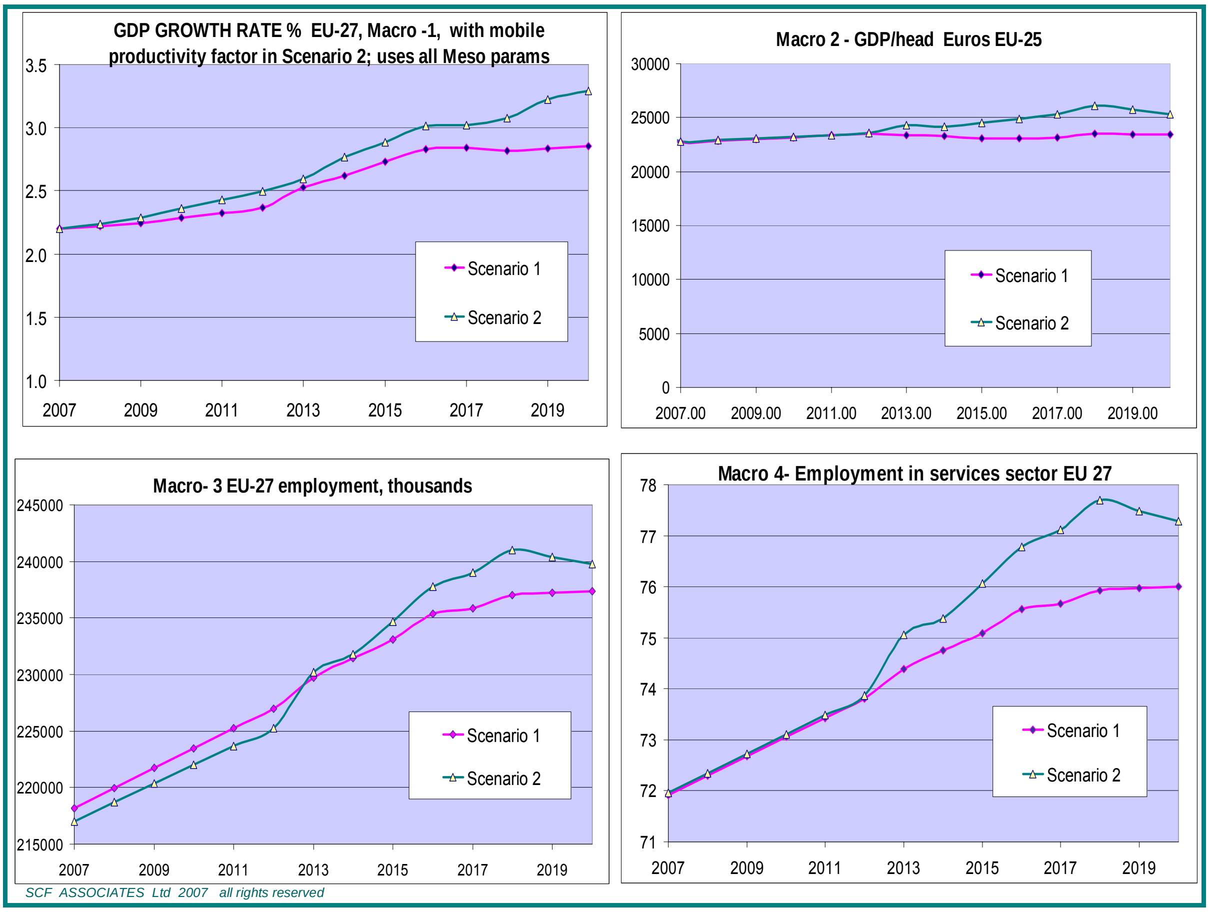
Note: An 'engineering' solution was used here – estimates were based on all meso economic parameters to produce the baseline data to which the scenarios could be applied.

The key shaping function applied here is a multiplier for 6% increase in productivity has been included each year over the years to 2012 due to mobile support for working, a figure based on recent empirical research.[18] We also assume that the real impact appears after 2012, and so is accelerated by the release of new spectrum and the higher density of penetration and usage that brings to the productivity of the EU, and all other things being neutral, to overall productivity growth. Such results are based on the premise that an increase in productivity

[18] See Mika Maliranta and Petri Rouvinen, 'Informational mobility and productivity: Finnish evidence', *Economics of Innovation and New Technology*, Vol, 15, No 6, September, 2006, pp. 605–616.

drives GDP growth and that this is a general effect across all sectors. Consequently a shaping function is added and is based on an accumulating 1% per annum GDP rate of growth increase due to current mobile, followed after 2012 to 2014 – when the spectrum is released – by prices of wireless working (mobile and fixed) tumbling for voice and Internet access services, leading to increased usage. Here we take an accumulative productivity impact of 2% per annum on GDP, which has run its course by around 2018, as it has then worked its way through the system.

Figure 4.8. Macro-economic parameters for the two scenarios



4.3 Discussion of findings and other economic impacts

From the above findings and analysis, the macro-economic impacts for the EU can be summarized as follows:

- Use of mobile provides major benefits for the EU economy, as measured in GDP growth, especially when its additional productivity factor is combined. After 2014 with cheaper services used more, we see the 2% factor in rate of growth of output per annum, then with VoIP, higher, as progressive take-up to 2018/2019 when the effect tails off.

- Overall employment is increased by mobile usage as the economy expands with extra productivity across all sectors, especially employment in the service sector

- The differences in EU employment in services and thus the knowledge worker industries, as a percentage of the workforce, favour the Mobile Market scenario, as would be expected. This is derived from regression with the Meso-1 and Meso-4 parameter of number of subscribers above saturation of 100% users – used as it may indicate richer services, more types of usages and more minutes of usage overall

- GDP/head also is positively affected by increased mobile usage resulting from use of the radio spectrum.

Supplementary research was also conducted to validate these results, specifically by comparing the direct effects of the mobile industry in terms of industrial output and employment with those of TV broadcast media.

Table 4.1. Comparison of the economic significance of the mobile and media sectors

Mobile as an economic driver – *the mobile provide*

		Economic significance for EU: Mobile	Economic significance for EU: TV
Direct →	▪Operators - services provision - revenues, SCF projected time series estimate	€208B, 2007	€43B, 2005[1]
	▪Suppliers/distributors - hardware (handsets), software, networks, content, estimate based on 2004 ratio [2]	€87B, 2007	€30B, 2006
	▪Economic output per MHz at 900 MHz [3]	€168 m, 2006	€ 28 m, 2006
Indirect →	▪Economic stimulus of mobile working, cumulative driving effect of mobile productivity to 2020 [4]	0.6% GDP Growth	Negligible
	▪Indirect stimulus to the economy by spend of direct impact revenues in other sectors ▪User surplus - Social and economic value – difference between what paid and prepared to pay ▪Producer surplus – difference between margins to stay in business and margins actually achieved	€165B, EU-27 2007 [5]	€95B [8]
Jobs →	▪Employment in sector	0.5 m [6]	0.4 m [7]
	▪Employment stimulated by spend from sector	2.3 m	1.8 m [9]

Sources : 1 OFCOM, 2006; 2 CEBR, 2004; 3 Vodafone/OFCOM, 2006; 4 M. Maliranta & P. Rouvinen, 2006; 5 Extrapolation from R. Mourik, 2003 ; 6 GSMA, 2004 ; 7 J. Cardona, 2002; 8 Estimate, OFCOM study, Europe Economics, 2006; 9 Pro rata estimate

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Note: The full sources used in the above table were as follows:
[1] *The International Communications Market,* Ofcom, 2006.
[2] *Contribution of Mobile phones to the UK Economy*, CEBR for O2, 2004.
[3] Vodafone submission to OFCOM consultation on the digital dividend, 2006.
[4] Mika Maliranta and Petri Rouvinen, 'Informational mobility and productivity: Finnish evidence', *Economics of Innovation and New Technology*, Vol, 15, No 6, September, 2006, pp. 605–616.
[5] Extrapolation from: Robert Mourik, 'Benefits of mobile telephony to society', GSM Europe seminar, November 2003, 2000 figures.
[6] *The Economic Contribution of Mobile Services in the Europe Union Before its 2004 Expansion*, Ovum for the GSMA, 2004.
[7] Jeannine Cardona, 'Cultural statistics in Europe: updates and trends', paper presented at UNESCO symposium on Statistics in the Wake of Challenges Posed by Cultural Diversity in a Globalization Context, Montréal, 21 October 2002.
[8] *Economic Impact of the Use of Radio Spectrum in the UK*, Europe Economics study for Ofcom, 2006, estimate.
[9] Pro rata estimate from mobile figures for employment in sector

5. Assessment of the impacts – a brief policy discussion

In real terms the digital dividend promises much for the future of Europe as it can deliver:

- Attractive spectrum[19] – which offers a combination of range (propagation) and capacity for many users (bandwidth)
- Good propagation – which means less infrastructure needed to provide coverage – reduces cost and improves service in higher attenuation conditions – in buildings and in rural areas
- Good capacity – so signals can be used for services that involve large information volumes for many of users – eg high-quality video, voice and data.

Thus in policy terms our analysis strongly suggests:

1. Investment in mobile via the digital dividend is the way forward for Europe

    - Contribution to productivity and GDP from investment in telecoms and especially mobile is much greater than anything else, as repeatedly shown in studies by Waverman, Maliranta and Rouvinen, Hardy, CEBR, NERA, Ovum, etc
    - GDP growth rate – order of 0.6% higher with mobile allocation over TV by 2020
    - Indicated Jobs –millions extra over the TV allocation scenario
    - Indicated GDP/head far higher by 2020

2. The case for investment in broadcast TV through spectrum is weak on economic grounds:

    - Investment in broadcast TV will not create as many jobs and wealth as investing in mobile
    - Investment in mobile would not halt technological investment in display devices – consumer electronics would continue with mobile spectrum allocation - new mobile TV, IPTV etc might even drive display devices more, including programming and technology for:
        - TV products – media recorders/players – DVD players and disks, MP3 players, etc
        - Network distribution
        - CATV

[19] We would recall here that in Europe the UHF band is conventionally divided into channels of 8MHz with that part often used for broadcasting ranging from channel 21 at the bottom to channel 69 at the top – or 470MHz to 862MHz – some 392 MHz. In some MS, only part of this band is used for analogue TV – for instance in the UK, 24MHz is used for radar, military and other uses. Optimal range and capacity combination is offered in the most valuable spectrum bands – these lie between 200MHz and 1GHz - the Ultra High Frequency (UHF) band. Nearly half of this spectrum is used to broadcast analogue television today on average, from some 470MHz up to around 850MHz.

- The broadcast paradigm of the past is less relevant to the future – because a plethora of other platforms can deliver content :
    - IPTV – over fixed xDSL/ FTTH
    - Internet media downloads for non-IP TV from WWW – and many fixed line operators are investing in NGNs with broadband capabilities
    - Mobile TV – cellular channels or broadcast elements
    - Wireless broadband fixed, and mobile

3. In view of the finding for a mobile allocation, it is hard to justify use of spectrum for HDTV on economic grounds and even on consumer demand grounds

- Real extra value to consumers – quality?
- Overall cost to consumers? Cheaper to implement HDTV on CATV, satellite and broadband networks
- Available through alternative platforms - broadband telecoms, cable TV and satellite, so just 'Me Too'
- Is the demand truly there?

4. With spectrum available for wireless broadband, Europe can close the Digital Divide using the new spectrum to provide access for all across the EU Member States bringing more capability:

- More bandwidth at lower cost – for broadband Internet access
- More advanced services - delivered over mobile/fixed wireless

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