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Simon Forge*, Colin Blackman** and Erik Bohlin***

Economic Impacts of Alternative Uses of the Digital Dividend

The switchover from analogue to digital TV broadcasting in Europe will release significant spectrum in the UHF bands. This "Digital Dividend" could have a significant impact on the EU economy, depending on its allocation. The following article offers an assessment of the alternatives.

With the switchover from analogue to digital TV broadcasting, Europe could benefit from the release of a very significant amount of spectrum, enough to give a new lease of life to the mobile – and to kick-start other industries. Sometimes called the "Digital Dividend", this spectrum offers a unique opportunity to meet new demands for services and to support the European agenda for innovation. Most importantly, it could have a significant impact on the EU economy, driving innovation, job growth, productivity and competitiveness. Economic analysis of the impacts of different uses of the spectrum is the key to deciding how such spectrum should be used.

A brief research study on this question was carried out in 2007. First it considered the economic factors involved in the Digital Dividend, from a micro- to a macro-economic European level. We compared the economic impacts of two different scenarios for allocating the Digital Dividend – "Broadcast TV Rules", in which 70% of the dividend goes to TV broadcasting and "The Mobile Bazaar", in which the mobile sector receives 60% of the freed spectrum. The approach built on a methodology developed by SCF Associates in several recent projects for the European Commission combining qualitative scenario building with quantitative economic forecasting.

Here, we briefly summarise the main findings concerning the long-term impacts on the European economy of alternative uses of the radio spectrum released through the Digital Dividend. The paper is structured as follows. First we explore the meaning of the Digital Dividend – its nature and possible uses for the spectrum that will be released. We then consider the two scenarios – one in which most of the spectrum is allocated for broadcasting, the other in which most is used for cellular wireless – forecasting the major potential economic impacts for these two options. Finally, the paper discusses the broad policy implications arising from the study's findings at a European level.

* SCF Associates Ltd, Princes Risborough, UK.

** Editor of "info", and "foresight", Cambridge, UK.

*** Chalmers University of Technology, Göteborg, Sweden.

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A Unique Opportunity for Europe

With the arrival of digital television (DTV), the proposed analogue switch off between 2010 and 2012 in the EU member states presents a one-time opportunity for Europe. This leads to a "Digital Dividend" since it will release significant segments of spectrum in the ultra high frequency (UHF) band. This is because:

- today, nearly half of the lower part of the UHF band (200 MHz-1 GHz) is used to broadcast analogue television in many member states, some 390 MHz – specifically the 470-862 MHz band;
- with DTV, all current analogue TV channels could be transmitted using only 25% – or less[1] – of the original spectrum, as illustrated below.

Potential Uses for Released Spectrum

There are many possible, and sometimes competing, uses for this valuable spectrum. These include wireless broadband links for rural areas to alleviate the digital divide, as well as digital terrestrial television, with which display products and content are associated (although the latter two items may be associated with any form of entertainment delivery such as Cable TV or web TV). Further contenders include the licence-exempt market – for hospital medical devices through scientific usages to home devices such as remote controls of all kinds as well as WiFi hotspots in homes

[1] Ofcom's Digital Dividend Review, 2006, noted that the 368 MHz of UK analogue broadcasting could be carried in just 40 MHz.

and public spaces. Naturally a major contender is the licensed cellular mobile industry, especially with its expansion into mobile multimedia and data services over future mobile broadband connections. New radio technologies – WiMax, Ultra-Wide Band, and ZigBee industrial networks, etc. – also compete for spectrum allocation.

Overall, some of the major possible applications that have been proposed include:

Digital terrestrial television

- more standard definition channels and programming (e.g. local, special interest)
- increased geographical coverage
- high definition TV
- mobile/portable reception
- data broadcasting.

Licence-exempt services and low-power wireless devices, e.g. for:

- programme-making and special events (PMSE), theatres, concerts etc.
- instrument, scientific and medial applications
- business networking, industrial sensor networks
- home applications (networking, low-power devices).

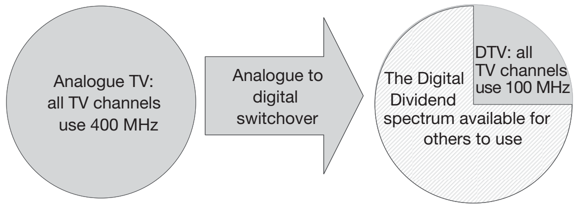
Wireless communications and services, including:

- cellular mobile
- wireless hotspots
- mobile multimedia, mobile TV
- wireless broadband, especially for rural areas to bridge the digital divide
- private mobile radio.

More specifically, releasing the spectrum to new users could offer new opportunities to Europe, for example:

Closing the digital divide: rural coverage for the EU with broadband at low cost has been the aim of industry and governments since the Lisbon agenda was first launched in 2000 to propel the EU towards a knowledge-based society. The Digital Dividend with its highly advantageous propagation characteristics (see below) is exactly what is needed for low-cost broadband for Europe's citizens. It can do far more than offer IPTV from the Web – it can stimulate the local economy with fast Internet access through mobile broadband.

Figure 1
With Digital Switchover, Current TV Channels Need Much Less Spectrum



Health and elderly care applications: our aging population and the increasing costs of hospital care are a double burden on EU society. New solutions are essential that can combine better care but at lower cost. One solution is to provide more care at home. In fact the "hospital in the home", or the less intensive elderly care through smart sheltered housing, can be effected using dedicated radio communications for monitoring vital signs of ill patients during recovery at home, as well as video surveillance. This approach would require a wide variety of broadband radio communications, from body area networks over a few metres, to home coverage networks, up to video relayed over several kilometres. Releasing the new spectrum could literally be a life-saver.

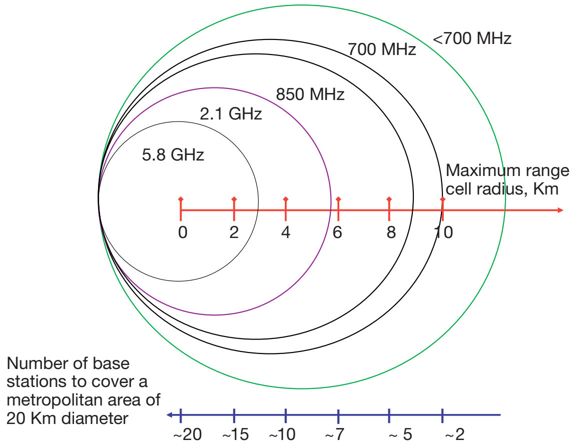
Flexible disaster recovery networks for global warming: again, in the area of vital applications for the new spectrum, our rapidly changing climate is bringing more frequent catastrophes. The effects of flooding, tornadoes, coastal erosion and other natural phenomena demand national and Europe-wide response networks. The frequencies should be appropriate for long-distance communications in poor weather (rain and wet foliage attenuation) but also for in-building rescue which needs propagation in ferro-concrete structures. Other countries (e.g. the USA) are already reserving bands for new emergency services in the Digital Dividend's UHF range, usually around 700 MHz, owing to these advantages.

The Propagation Characteristics of Frequencies

Broadcast TV, much of which is still analogue in the EU, currently enjoys the major share of some prime spectrum.[2] The prime 200 MHz to 1 GHz spectrum band in one European Union member state is used for terrestrial television (46%), the military (26%), public

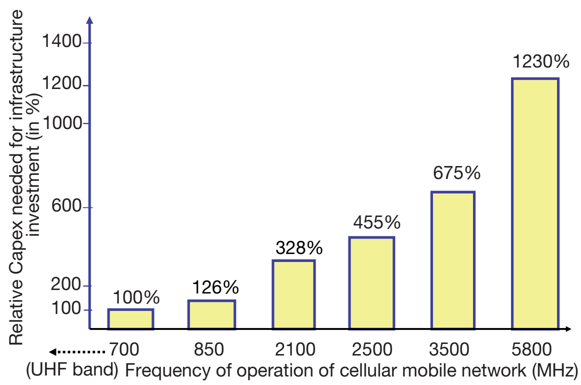
[2] In Europe the UHF band is conventionally divided into channels of 8 MHz. Broadcast TV ranges from channel 21 at the bottom to channel 69 at the top, or 470 to 862 MHz, or some 392 MHz.

Figure 2
The Propagation Characteristics of Spectrum



Source: BBC R&D.

Figure 3
Lower Frequencies Reduce Costs of Infrastructure and Communications



Source: BBC R&D.

mobile (9%), private business radio and other (7%), aeronautical/maritime (6%), emergency services (2%) with some 4% for digital radio, science and licence-exempt applications.

This spectrum is very valuable, particularly to wireless operators, because of the propagation characteristics of these frequencies. They offer an optimal combination of range and data capacity. For example, at 3.5 GHz, the signal covers a reception radius, or cell size, of about 5 km while at 700 MHz it is about 10 km (cf. Figure 2).

In economic terms these features determine infrastructure cost. Better propagation means fewer base stations. Thus the network infrastructure investment (CAPEX) is nearly seven times higher if wireless operators have to use 3.5 GHz compared to the larger cell sizes at 700 MHz, or even higher at the lower frequencies in the Digital Dividend (cf. Figure 3).

Moreover, improved propagation qualities also mean better reception for mobile phones *inside buildings* – a factor that may hold back the substitution of wireless for fixed-line communications in the future. Thus the UHF band has particularly valuable properties for wireless communications networks, using any generation of technology – whether it be 2G cellular, 2.5G, 3G or 4G or, as we look to the future, novel radio technologies such as WiMax or WiFi. As already indicated, it could also stimulate innovation in newer European radio technologies for emergency communications, health, care of the elderly and lower-cost communications.

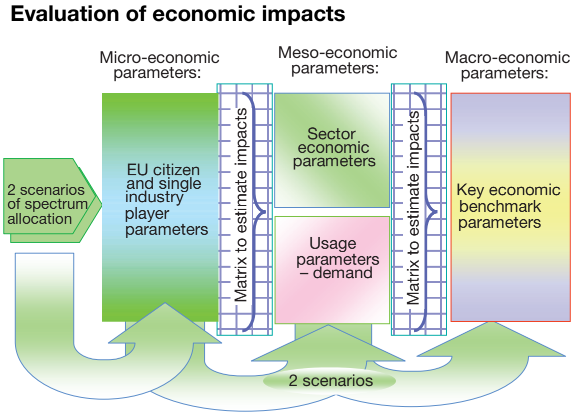
Estimating the Economics of the Digital Dividend

Translating the potential impacts of the propagation characteristics of the Digital Dividend into economic terms is a logical and metrical challenge. Like any kind of industrial development, the growth in industries producing information and communication technology (ICT) goods and services is thought to be important to the general growth of the economy in terms of their impacts on other sectors. But as many researchers have found, measuring the impact of any kind of ICT is difficult, owing to the problem of identifying linkages between these economic inputs and their impacts.

Our study uses scenarios to build a qualitative picture of alternative futures. 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. There are many ways of building scenarios. Our approach[3] is based on a formalisation of several of these, built up over some fifteen years of looking at future directions of markets, high technology sectors and the economy. It consists of creating a key theme and its drivers, then working through assumptions and assertions and several further stages towards the full scenario.

[3] Cf. S. Forge, C. Blackman, E. Bohlin: Constructing and using scenarios to forecast demand for future mobile communications services, in: foresight, Vol. 8, No. 3, 2006.

Figure 4
Overall Methodology of the Study



The approach 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. Figure 4 sets out how the variables in the project are interlinked and aggregated.[4]

Clearly the choice of appropriate parameters at each economic level (micro, meso, macro) as indicators for measurement is one of the keys to the 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 the SMART objectives[5] used in EC impact assessments. With this in mind we have constructed a quantitative approach for extrapolating from qualitative scenario building, using our previous experience in this domain. This quantitative approach is based on linking micro-economic factors to macro-economic ones via an intermediate level, that of a sector or social group, the meso-economic level.

We spent significant time in researching the availability of data to support possible parameters before deciding which were most proportionate to policy objectives. At the micro-economic level, we use parameters related to consumer behaviour. We collected data on consumer expenditure on communication and media, measured e.g. by mobile ARPU, TV and Internet/broadband spending as a percentage of total household expenditure on *e*-communications. At the meso-economic level, we considered growth indicators of media and wireless sub-sector-penetration in the EU27, e.g. the growth of wireless industries, penetration of TV receivers, TV and mobile sector revenues. Finally, the macro-economic parameters focus on European GDP and employment, measured by EU GDP growth rate, EU employment, and EU employment in services as a percentage of total employment. At each level, parameters were calculated for forward simulations over the period 2007 to 2020.

The Use of Scenarios in Exploring the Options for the Digital Dividend

Our main findings were based on an examination of the scenarios to interpret the potential outcomes of the various spectrum policies. By their very nature, scenarios are only *stories about the future* and no more – they are stories of what is likely to happen, even if it seems unexpected. However, in using scenarios as a basis to guide quantitative forecasting, the limitations in the availability and quality of the quantitative data is just as important in limiting accuracy when extrapolating future time series as it would be if scenarios were not used. However, 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 our 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.[6] Levels of competition really set the scope and form of market behaviour that spectrum allocation unleashes in that they determine:

- 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.

[4] A more detailed examination of this method is given in the Methodology Report for the study, which may be obtained from www.digital-dividend.eu.

[5] SMART: Specific, Measurable, Accepted, Realistic and Time-dependent objectives.

[6] Cf. for example, T. W. Hazlett, J. Muller, R. Munoz: The social value of TV band spectrum in European countries, in: info, Vol. 8, No. 2, 2006, pp. 62-73.

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

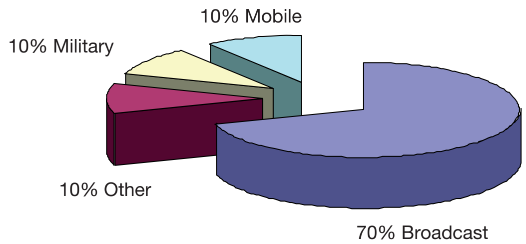
The options for allocating the Digital Dividend are presented in the form of two scenarios, which model the extremes in some senses, and their impacts on the economy. The two scenarios created to contrast the allocation of the digital dividend were as follows:

Scenario	Theme
Broadcast Media Rules	Most of the dividend is used for additional digital terrestrial channels and HDTV
Mobile Bazaar	A significant proportion of the spectrum is released via a licensed spectrum regime for mobile communications services. This gives a bazaar in spectrum trading and a wide variety of new opportunities for growth of mobile services, and the economy dependent upon them.

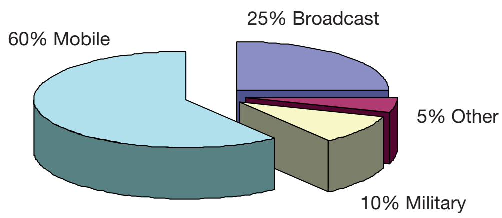
We contrasted the different amounts of spectrum from the Digital Dividend allocated within each scenario to the various applications in Figure 5. Note that both scenarios allow for at least 15% of the released spectrum to be used for other purposes, such as military.

Figure 5
The Two Scenarios and the Allocation of the Digital Dividend

Scenario 1 - Broadcast Media Rules :



Scenario 2 - Mobile Bazaar :



Quantitative Results

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. However, as many other researchers have found, measuring the impact of any kind of information and communication technology is difficult, due to the problem 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 Solow Paradox, identified in 1987.[7] 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 "Solow Productivity Paradox". 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.[8] 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".[9]

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.

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

[7] 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 J. Triplet: The Solow Productivity Paradox: What do Computers do to Productivity?, in: Canadian Journal of Economics, Vol. 32, No. 2, April 1999, pp. 309-334.

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

[9] D. Crafts: The Solow Productivity Paradox in Historical Perspective, CEPR Discussion Paper 3142, 2002, Stanford University.

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

[11] L. Waverman, M. Meschi, M. Fuss: The impact of telecoms on economic growth in developing countries, in: Africa: The Impact of Mobile Phones, The Vodafone Policy Paper Series, No. 2. http://web.si.umich.edu/tprc/papers/2005/450/L%20Waverman%20Telecoms%20Growth%20in%20Dev.%20Countries.pdf.

Brynjolfsson has shown evidence[12] 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 have 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.[14]

SMART Objectives:

Specific: Objectives should be precise and concrete enough not to be open to varying interpretations. They must be understood similarly by all.

Measurable: Objectives should define a desired future state in measurable terms, so that it is possible to verify whether the objective has been achieved. Such objectives are either quantified or based on a combination of description and scoring scales.

Accepted: 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.

Realistic: 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.

Time-dependent: Objectives and target levels remain vague if they are not related to a fixed date or time period.

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

We would also 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 starting-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 been collectively termed “driving in the rear-view mirror” in that they rely overmuch on past time series; so we are anxious to restrict the 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. This would be unreal as it would forecast continued expansion forever, whereas expansion should be limited and/or decline at some point, based on decisions from experience, and /or common initial conditions.

Thus, our initial analysis enabled us to make a selection of parameters at a general level, as follows. For the micro-economic parameters we employed demand-side variables, based on usage and expenditure on such usages. At the level of meso-economic parameters we concentrated on two sectors: firstly, that of the mobile industry, which gave the supply-side view, with its penetration by unit sales to indicate take-up, and thus a measure of its support for a productive infrastructure for the economy, also indicated by the parameter of its revenues; secondly, we examined the sales of TV receivers in terms of units and revenues, to try to gauge their linkage to the economy. Finally we chose those macro-economic parameters which are

[12] E. Brynjolfsson, S. Yang: Information technology and productivity: a review of the literature, Advances in Computers, Vol. 43, 1996, pp. 179-214; S. Aral, E. Brynjolfsson, 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; E. Brynolfsson, B. Kahin (eds.): Understanding the Digital Economy, MIT Press, Cambridge 2001.

[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 791, June 2005, p. 20.

Table 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$, EU27	1. Growth of wireless industries (WiFi hot-spots)	1. EU GDP growth rate
2. TV spend as % of total household spend on e-comms	2. Millions of TV receivers	2. GDP/head (euro/inhabitant)
3. Internet/BB spend as % of total spend	3. TV revenues	3. EU employment
4. Mobile spend as % of total spend	4. Handset sales	4. EU employment in services as % total employed
	5. Revenue from mobile communications	

general indicators – employment, GDP and variations such as employment in knowledge-based industries.

We then spent significant time in researching the availability of data to support possible parameters (see 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 on the efficacy of such parameters through a limited survey of 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 1.

At each level, parameters were calculated for forward simulations over 2007 to 2020. 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 (i.e. the status quo in spectrum allocation) before applying the spectrum impacts for each scenario.

The rationale for their choice and subsequent behaviour in qualitative terms was as follows. For the micro-economic parameters, the first one, Mobile ARPU (average revenue per user), was measured in US$ for the EU27. Although release of spectrum under any scenario has some effects on usage as pricing becomes better value, it soon saturates. Increasing ARPU stabilises under forces of competition and saturation. With mobile VoIP, prices would descend rapidly, 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. As for the second micro-economic parameter, TV spend as a percentage of total household spend on e-communications, this may tend to increase in the future due to outlays for a set top box (STB) for DTV and new screens/ VCR, and also for satellite and CATV subscriptions. However, spend may then shrink, under less use of broadcast with greater competition from other TV media, so the percentage of household spend declines, as spending finishes and competition bites on subscriptions (e.g. IPTV from programming over the Internet) as well as other non-broadcast TV operators. The net impact would reduce costs as a whole to the household, while no new spend for TV items (services or products) can be expected to appear.

For the third micro-economic parameter, Internet/broadband connection, measured as spend as a percentage of total household spend on e-communications, this would tend to increase rapidly, especially with downloads, IPTV etc. However, later (after 2012) it may saturate, as mobile Internet spend in terms of ARPU tends to reduce with competition, especially with flat pricing for any volume of usage in a flat monthly charge – and so reduces overall spend percentage and as IPTV starts to replace terrestrial TV. With the arrival of a mobile internet beyond 2012/2014, Internet and broadband spend would change to become a part of the mobile percentage of total spend on e-communications while Internet access prices in general would come down with competition.

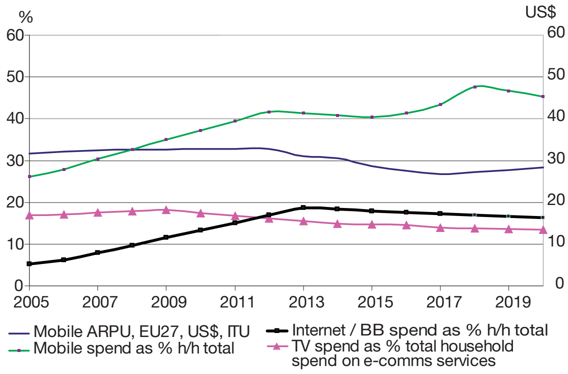
In the case of the fourth micro-economic parameter, mobile spend as a percentage of total household spend on e-communications, the trend expected is that, as disposable income rises but mobile prices stagnate, so the total proportional mobile spend would decrease faster as a percentage of the net household spend. However, there is a second compensating trend of mobile replacing more of fixed live e-communications as a total spend percentage. The net effect is that mobile spend would tend to stay constant due to an increased use for mobile internet access. Furthermore, after 2015, take-up of new services may expand rapidly, acting either to maintain spend despite competitive price-cutting in base services, or to drive new extra revenues through additional household spend.

The projections for future micro-economic parameters are formed using two inputs. Firstly, 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 of typical behaviour, and thus a start series for forward linear trajectories. Secondly, the influences of the above trends, with their impacts on what might otherwise have been simple linear growth for 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 in Figure 6 with the Y-axis referring to each parameter unit as given in the legend for the four parameters.

We can then apply the scenarios to the micro-economic parameters, shown in Figure 7 in a setting simulating the expected parameter behaviour of the scenarios against the baseline, up 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.

The profiles 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 become widespread. Thus proportional spend on other services such as TV (Micro 2) would tend to go down in

Figure 6
Base Cases for Micro-economic Parameters to 2020



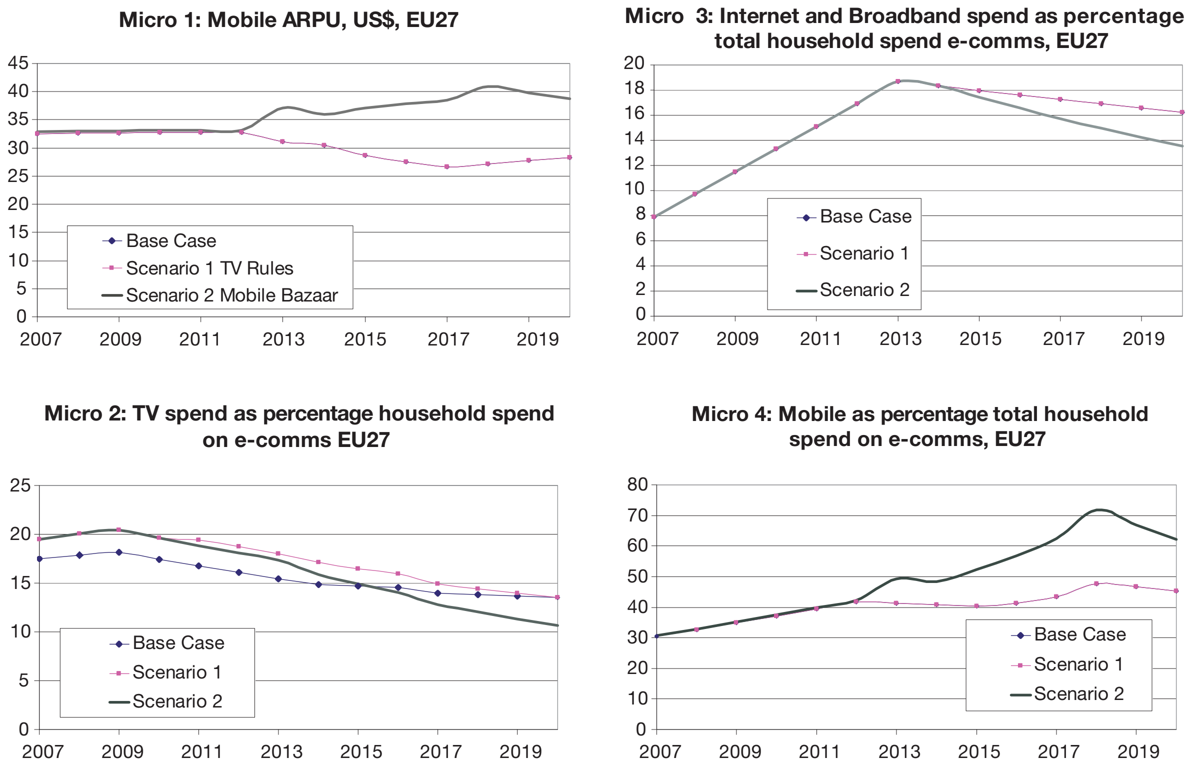
Scenario 2, as does broadband Internet spend as Internet access via mobile becomes more important in Scenario 2 with extra spectrum for mobile Internet.

From the past time series for both meso and macro we also produce the linking mechanisms for forward projection, as outlined in Figure 5 on the methodology. We generate the cross-correlation coefficients[15] 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. One problem with such results is the very strong correlation in some cases. This was taken as indicative rather than literally, because, as previously emphasised, the sample range is very short for highly robust results.

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, for each micro variable against each meso variable 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. Scatter charts can highlight whether there is a simple linear correlation between micro and meso-economic parameters with linear regression lines to guide simulation of future behaviour. Such scatter charts can give an indication of

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

Figure 7
Micro-economic Parameters under Scenario Conditions



the *form* of the relationship, where there is a strong relationship as given by the correlation coefficients, and can show that relationship as a regression line. Those graphs suitable for future extrapolations were identified. Note that the regression used throughout was of the simplest type, that of a linear relationship, y = mx + c formula, whose dependent variables are stated in Figure 7 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 of their behaviour in each scenario for all meso parameters. We now examine the assumptions and logic used to shape the projected behaviour.

For the first meso-economic parameter, the number of EU27 WiFi hotspots, used as an indication of growth of ICT and Internet uptake, the initially expected profile is of strong early take-off growth, continuing to 2014. Then a constant mature growth profile is followed with the increase slowing as density of usage saturates across most of the EU27. We then apply the scenarios to produce differentiated results for each parameter profile. Key assertions behind the shaping functions used to produce the future graphs here have the following rationale. In Scenario 2, the Mobile Bazaar, competition from mobile broadband using its allotted extra spectrum tends to replace WiFi hotspots, so the number could peak and decrease as the maximum point is met earlier than in Scenario 1. This is the impact of the mobile Internet, really felt after 2014, so growth slows in Scenario 2, as Internet access transfers to mobile carriers and away from WiFi. This contrasts with Scenario 1, where the lack of spectrum for broadband mobile and Internet access maintains a continued slow growth in numbers of installed WiFi hot-spots for roaming users and in the home/office.

The second meso-economic parameter, TV receivers in the EU (in millions of units) exhibits a quite sharp increase, due to replacement sales for DTV migration over 2011-2015, then saturation around 2016 and stagnation afterwards. By then, home TV usage has morphed the TV set into a multiple function terminal including Internet access, video conferencing, mobile phone accessory as well as download IPTV display. However, laptops may be used as entertainment TVs by many, as is already the case for Web TV and social networking sites with video clips such as You Tube. We now apply the scenarios. Key assertions shaping these future graphs have the following rationale. In Scenario 2, based on impacts of Mobile TV, IPTV over mobile Internet access etc. causes an initial hiccup in TV sets in use and sales, 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 but total numbers of TV sets in use are still significant as entertainment centres, and new mobile channels also drive TV sales as a screen for display of off-air content as well as on-air. However, projection direct from mobiles also may tend to replace standard flat screen TVs and reduce sales, and moreover rolled or folded flexible screens using "electronic paper" may appear, integrated as part of the handset. In contrast to Scenario 1 (the DTV allocation of spectrum) TV set sales still constantly rise, but quite slowly, as market saturation is reached.

For EU27 broadcast TV revenues (in € billion), the third meso-economic parameter, these are expected to increase slowly but stagnate as viewer saturation arrives around 2015 with a slow decline as TV traditional revenues are dispersed to multiple sources and content providers. Moreover, some web TV competition may be felt, impacting viewing figures, especially as it would enable more peer-to-peer entertainment content, such as social networking site videos. We now apply the scenarios with key assertions behind the shaping functions with the following rationale. Generally TV revenues for broadcast decline as other channels (not just Web TV but also CATV and Satellite TV, plus gaming etc.) take up viewer demand. However, in Scenario 1, more spectrum should allow more broadcast terrestrial DTV services – and as long as they are taken up, more revenues, so in terms of levels of broadcast TV revenues, Scenario 1 tends to lead over Scenario 2.

A continued increase, slowing with saturation from 2011, is expected for the fourth meso-economic parameter, EU27 mobile handset sales 2002-2011, (in million units), using historical data based on Western Europe. The key driver is replacement sales on a 2-3 year lifecycle for 500-600 million units as the installed base, despite the move to new smartphones and the future models of simplephones from 2011/2014. We then apply the scenarios to produce differentiated trajectories assuming that availability of Internet access from 2012 tends to increase sales, also driven by high take-up of useful media/Internet services in moving video full colour, with projectable high resolution. However, sales growth declines from 2017, as a phase of saturation for the new handset models is entered.

The fifth meso-economic parameter, revenue from mobile communications (in US$ billion), is expected to increase until impacts of new VoIP mobile are felt, so that user saturation of minutes is reached despite new applications after 2012 and 2015 which maintain minutes but not spend – as mobile Internet access becomes the major usage. It includes mobile-VoIP (as for Skype) which decimates conventional voice revenues. We then apply the scenarios to produce differentiated results for each scenario with the assertions behind the shaping functions having the following rationale. Net EU27 mobile revenue rises in this scenario although prices per unit of mobile service may fall, but to compensate, overall usage increases, until VoIP enters, forcing a massive decline in prices paid for voice calls. So mobile revenues after 2015 are only maintained via new demand for useful extra services at affordable prices, exploiting data transmission to a larger extent, probably requiring serious analysis of the real utility of the new services by the operators and better research on user interfaces.

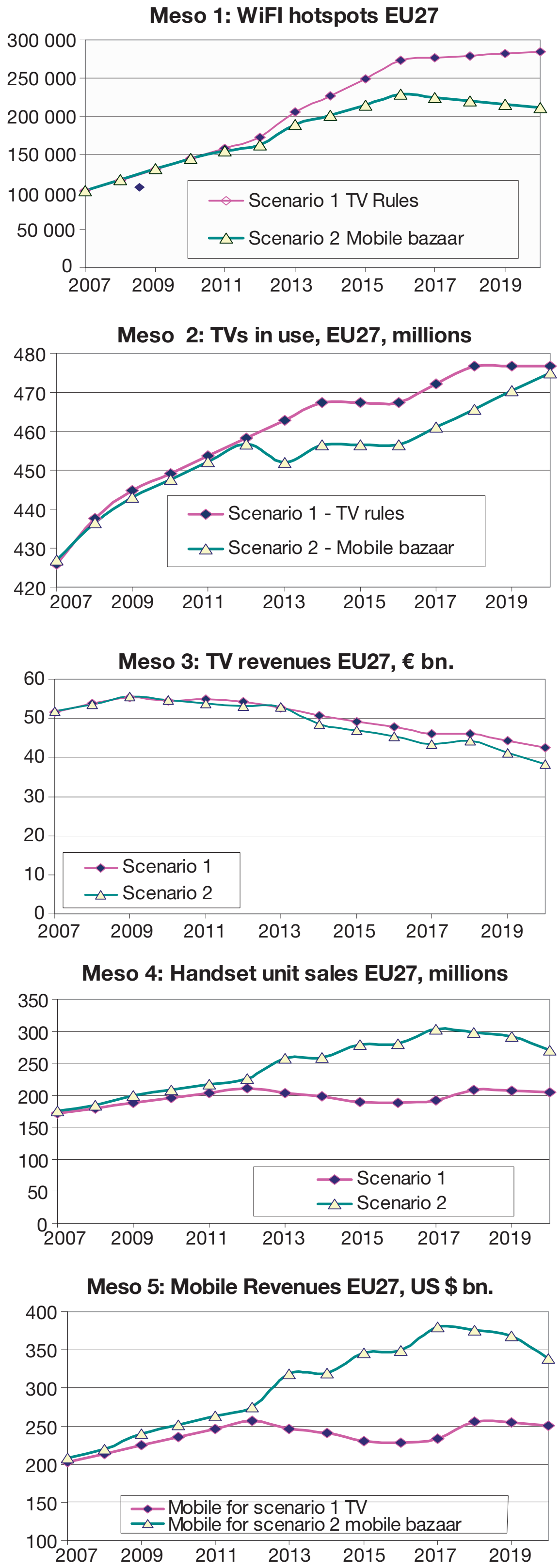
Results for the final future series for the five meso parameters are shown in Figure 8.

We may now estimate the macro-economic parameters, using the past series correlated with the historical meso-economic data to produce the following cross-correlation coefficients. This produced a much more problematical result. The cross-correlation coefficients found between the time series for meso and macro-economic parameters displayed strong links in some cases – but GDP growth was a difficulty (as always!) No strong correlation with meso parameters was shown, except perhaps with WiFi Hotspots, which seemed to follow a reasonable train of logic. The regression lines also highlighted a similar lack of real relationships between variables. 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. Thus 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.

A key shaping function has also been applied to GDP growth for Scenario 2, the Mobile bazaar. A multiplier for a 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.[16] We also assume that the real impact appears after 2012, and so is accelerated by the re-

[16] Cf. M. Maliranta, P. Rouvinen: Informational mobility and productivity: Finnish evidence, in: Economics of Innovation and New Technology, Vol. 15, No. 6, September 2006, pp. 605–616.

Figure 8
Meso Parameters to 2020



lease of new spectrum and the higher density of penetration and usage that contributes to the productivity of the EU and, all other things being equal, to overall productivity growth. Such results are based on the premise that an increase in productivity 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 due to current mobile, followed after 2012 to 2014 – when the spectrum is released – by prices of wireless (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. A summary of the macro-economic results is given in Figure 9.

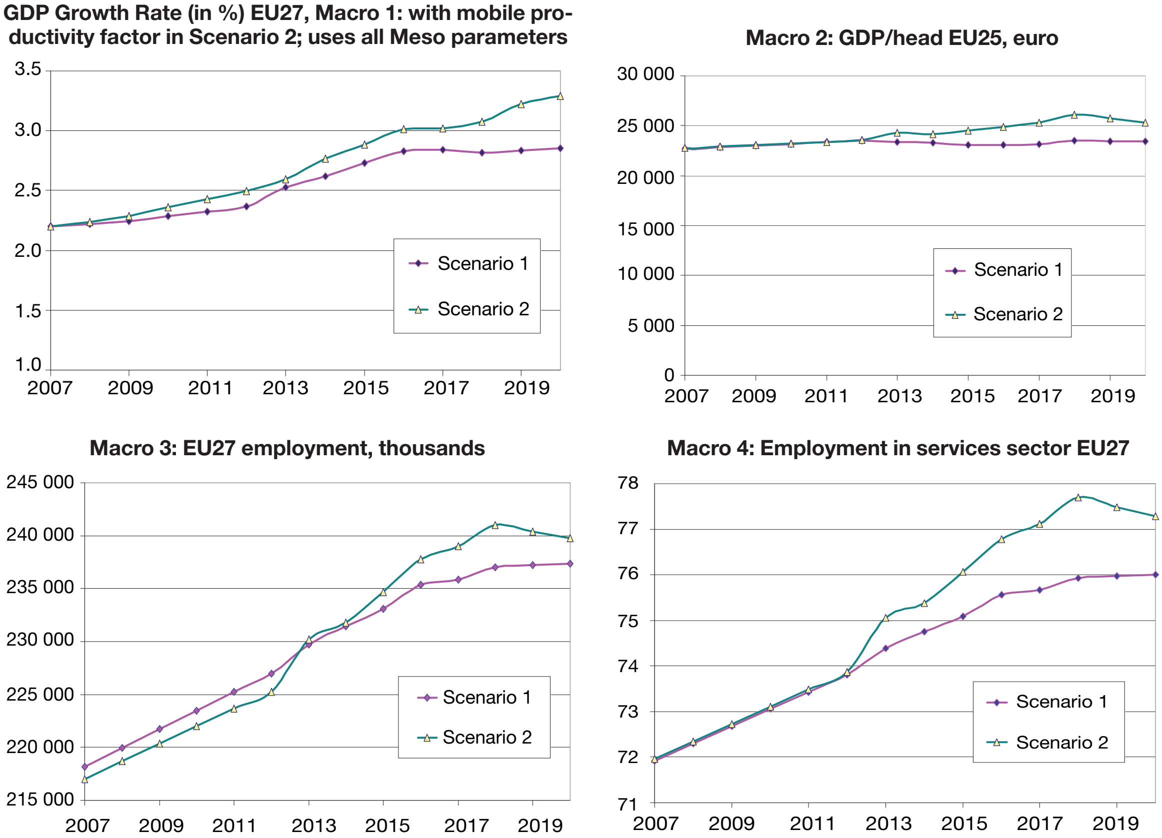
Discussion of Findings and Other Economic Impacts

From the above findings and analysis, the macro-economic impacts for the EU can be summarised 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 cheaper services lead to more intensive use, hence the 2% factor in rate of growth of output per annum. Then with VoIP, the rate of growth is higher due to 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. This holds especially for 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 parameters of number of subscribers above saturation of 100% users – as it may indicate richer services, more types of usages and more minutes of usage overall.
- GDP/head is also positively affected by increased mobile usage resulting from use of the radio spectrum.

Supplementary research was 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.

Figure 9
Macro-economic Parameters for the Two Scenarios

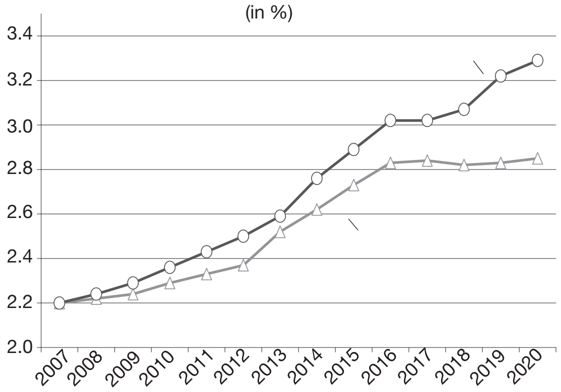


Thus the key finding of the study is that use of the Digital Dividend by the mobile sector is highly positive for the European economy over the next decade and more. By comparison, use of the released spectrum by broadcasting has much less impact on the economy. The difference in results arises mainly from the significant productivity gains throughout the EU economy, coming from the investment in wireless communications, which will drive GDP growth rates higher. This is a cumulative effect over at least a decade, which accelerates with lower priced services (cf. Figure 10, an expansion of the first graph of Figure 9).

Further results from scenario modelling show other positive impacts for Europe of allocating spectrum for wireless communication services. Total employment, the proportion employed in services (an indicator of knowledge-based work), and GDP per head are all more closely associated with mobile sector use of spectrum. The macro-economic impacts for the EU can be summarised as follows:

- The use of mobile services provides major benefits for the EU economy, as measured by GDP growth, especially when its additional productivity factor is combined. After 2014, with cheaper services, the rate of growth of annual output takes off further as prices fall with the introduction of mobile VoIP and its progressive take-up to 2018/2019, when the effect starts to diminish.
- 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, indicating use of richer services, more types of usage and more minutes of use overall.
- GDP/head is also positively affected by increased mobile usage resulting from better use of the radio spectrum.

Figure 10
The Impact of the Two Scenarios on Europe's GDP Growth Rate
(in %)



Supplementary Research on the "Mobile Provide"

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. In comparing the differences in impacts of the two scenarios – dominance by broadcast TV or mobile – Table 2 shows that mobile spectrum allocation could generate more direct and indirect economic benefits as well as stimulating greater direct employment in the wireless sector. Furthermore, investment in mobile brings enormous indirect economic benefits through the economic stimulus of mobile enabled working, a primary economic difference between the two choices in driving the EU economy.

Implications for Europe

Overall, our approach to a framework for assessment of the economic impact of spectrum allocation and for proposals on how best to exploit the new spectrum for efficiency gains indicates that:

- Investment in wireless communications could bring significant productivity gains throughout the European economy, resulting in faster GDP growth rates up to 2020. Approximations indicate that accumulated effects over the next decade or more might have a significant impact. Estimates of the accumulated effect indicate as much as an additional 0.6% GDP growth per year for the EU economy by 2020 in the mobile case when compared with broadcast TV. This cumulative effect would tend to increase with lower priced services.
- If we look at current performance as an indicator of future economic impact, we can see that the use of the Digital Dividend by the mobile sector could be much more advantageous for the EU. For instance:
  - The economic output per MHz of bandwidth is estimated at €168 million for mobile compared to €28 million for the digital TV case.
  - Direct economic effects in the EU (services, revenues, product sales etc.) for operators are currently estimated to be €208 billion for mobile compared to €43 billion for broadcast TV. Suppliers presently directly benefit by sales of €87 billion in the mobile case versus €30 billion for broadcast TV.
  - Indirect economic effects throughout the EU, such as user and producer surplus, are estimated at €165 billion for mobile against €95 billion produced by broadcast TV.
  - Investment in broadcast TV will not create nearly as much wealth or as many jobs as investment in mobile. Employment in the mobile sector is growing strongly and already outstrips employment in TV broadcasting, which is stagnating.
  - Spending by the mobile sector already stimulates 2.3 million jobs in other industries, a figure well in excess of the estimated 1.8 million resulting from TV sector spending.

The implications of the above are that investment of the Digital Dividend in mobile rather than media broadcasting will be far more beneficial for the EU economy and so clearly the way forward is mobile because:

- The contribution to productivity and GDP from investment in telecoms and especially mobile is much greater than anything else, as confirmed by a range of economic modelling studies.[17]
- GDP growth rate: cumulative effects lead to a significantly higher rate of growth in GDP with mobile allocation by 2020. Similarly, the cumulative effect on average GDP per head across the European Union is significant.
- Jobs created: mobile investment results in jobs in the mobile industry but more importantly more jobs in mobile user industries. The net impact is millions more additional jobs likely to be created by mobile compared with broadcasting over the next decade.

[17] See, for instance, studies by Waverman, Maliranta and Rouvinen, Brynjolfsson, Hardy, CEBR, NERA and Ovum; CEBR: The Contribution of Mobile Phones to the UK Economy, study for O2, London 2004; NERA: The Economic Impact of the Use of Radio in the UK, Report for the Radiocommunications Agency, 1995; Ovum: The Economic Contribution of Mobile Services in the European Union Before its 2004 Expansion, Report to the GSM Association, London 2004.

Table 2
Mobile as an Economic Driver – Comparison of Direct and Indirect Economic Impacts on the EU Economy – the "Mobile Provide"

Comparison of the economic significance of the mobile and media sectors		Economic Significance for the EU	
		Mobile	TV
Direct	Operators – service provision, SCF projected time series estimate	€208 billion (2007)	€43 billion (2005)[1]
	Suppliers/distributors – hardware (handsets), software, networks, content, estimate based on 2004 data[2]	€87 billion (2007)	€30 billion (2006)
	Economic output per MHz at 900 MHz[3]	€168 million (2006)	€28 million (2005)
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, i.e. difference between what paid and prepared to pay • producer surplus, i.e. difference between margins to stay in business and margins actually achieved	€165 billion (2007)[5]	€95 billion[8]
Jobs	Employment in sector	0.5 million[6]	0.4 million[7]
	Employment stimulated by spend from sector	2.3 million[9]	1.8 million[10]

Notes: [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] M. Maliranta, P. Rouvinen: Informational mobility and productivity: Finnish evidence, in: 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; [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.

In comparison, the case for investment in broadcast TV through spectrum from the Digital Dividend is weak on economic grounds:

- Investment in broadcast TV will not create nearly as much wealth or as many jobs as investment in mobile (cf. Table 1).
- Even so, investment in mobile would not halt technological investment in display devices – consumer electronics would continue with mobile spectrum allocation – new mobile TV and IPTV might even drive display devices more, including programming and technology for:
  - TV products, media recorders and players (DVD, hard-disk, MP3 players etc.)
  - network distribution
  - cable and satellite TV.
- In reality the broadcast paradigm of the past is becoming less and less relevant to the future. When distribution channels were limited, a one-to-many model was the solution, but technology and society have moved on. A plethora of other platforms can now deliver content:
  - IPTV – over fixed xDSL or fibre to the home (FTTH)
  - Internet media downloads for non-IP TV from the Internet especially via next generation networks (NGN) with broadband capabilities
  - mobile TV – cellular channels or broadcast elements
  - wireless broadband, fixed and mobile.

The TV sector's argument in favour of using the released spectrum for HDTV is difficult to justify on economic grounds and even on consumer demand grounds:

- HDTV is already available through alternative platforms – broadband telecoms, cable TV and satellite, so demanding spectrum for making DTTV into HDTV is just a "me too" play.
- Consumer demand for better quality pictures has yet to be established. This is because consumers who currently receive free-to-air channels seem unwilling to pay for HDTV. If, however, TV viewers are willing to pay, then alternative platforms may be better placed to deliver. If they are not, we question whether taxpayers' money should be used to subsidise HDTV entertainment.

Consequently, the study shows that the release of a major part of the Digital Dividend to broadcast DTV cannot be justified in either economic or social terms.

In contrast, the mobile sector can use the Digital Dividend to the benefit of Europe both economically and socially. In particular, allocating spectrum to enable wireless broadband could have a dramatic impact on bridging the Digital Divide by using the new spectrum to provide access for all across the EU's 27 member states. In short, the Digital Divide can be closed through the "Mobile Provide".