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What is the digital dividend?
State of play in Europe

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Summary

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Introduction

In recent years, there has been rapid development in the Information and Communication Technology (ICT) sector, which has given birth to a huge variety of new services. In particular, the last twenty years have seen an exponential growth of mobile usage across the globe, with an explosion in terms of products, applications and contents offered by operators. Society is becoming more mobile, so more radio spectrum is required for the provision of mobile services. In fact, mobile communications rely on the use of the radio spectrum.

Radio spectrum is a public resource, conventionally defined as the portion of electromagnetic spectrum characterised by waves with frequency varying between 3 kHz and 3000 GHz. In each country, these frequencies are allocated to different public and private services with the aim to pursue a wide range of economic, social and scientific purposes. It is used for mobile, fixed and satellite wireless communication, transport, radiolocation, many applications such as alarms, microphones and medical equipment, radio and television broadcasting which, in particular, has become one of the main sources of information for most people in the world. Specific frequencies are allocated to deliver public services such as defence, public safety, disaster warning, air-traffic control, maritime navigation, weather forecasts; and scientific activities, for instance radio astronomy and space research.

Among other unique properties, spectrum is considered a scarce resource, namely it has limited availability. In fact it is subject to congestion, as signals transmitted on the same or adjoining frequencies at the same time and in the same location can cause interference, which reduces or nullifies the usability of spectrum.

It is worth clarifying that radio spectrum is an artificial entity, an abstract mathematical idea introduced by the French mathematician and physicist Jean-Baptiste Fourier (1768-1830). It is not an existing and limited resource that has to be shared between different and more and more usages. It is actually the result of the regulation and the management of a universal natural phenomenon: radio waves.

Given the propagation characteristics of radio signals, limitation in the use of the radio spectrum is mainly due to the lack of availability of proper technologies and equipment, and frequency bands fitting for each type of service. Instead of saying that it is scarce, radio spectrum can be considered a “permanently constrained resource”. Scarcity can be seen as a cyclic problem that has to be faced periodically.

The necessity of coordination and regulation was immediately recognised, at the national and international level, for the effective use of radio communication. Many services work worldwide, so a certain level of uniformity in the allocation of spectrum to services between countries is required. Moreover, radio emissions used for systems within a country are not confined by national borders, as in their propagation, waves do not recognise boundaries, so they can cross frontiers and cause unwelcome interference. Coordination is also necessary within the country in order to ensure the equitable access to spectrum by different services without

creating constraints, which would impede the effective provision of services by each operator.

Along with continuous technological changes and improvements that increase spectrum capacity and make spectrum better usable, more efficient and effective spectrum management approaches are needed. An improper management approach can determine a suboptimal allocation of spectrum, creating artificial shortages and surplus across spectrum, leaving spectrum bands underused or misused. Basically, technological progress, spectrum management and demand of existing and new services together determine the use of radio frequencies. The goal is to actively find the right balance between them, in an extremely dynamic environment.

With regard to technological progress, the recent introduction of digital television (DTV) services is considered the most important development in the television field after the introduction of colour television in 1950s. With the advent of DTV, terrestrial broadcasting has become the centre of world attention, as digital terrestrial television (DTT) uses spectrum far more efficiently than analogue terrestrial television, requiring a smaller amount of spectrum in order to transmit the same content. The transition from analogue to digital terrestrial broadcasting has been occurring all over the world.

With this transition process, a significant part of the radio spectrum in particular in the UHF band has been freed up. These frequencies can be used for the provision of other services, in particular mobile services. The amount of spectrum that is above that nominally required to accommodate existing analogue television services in a digital form is defined as digital dividend.

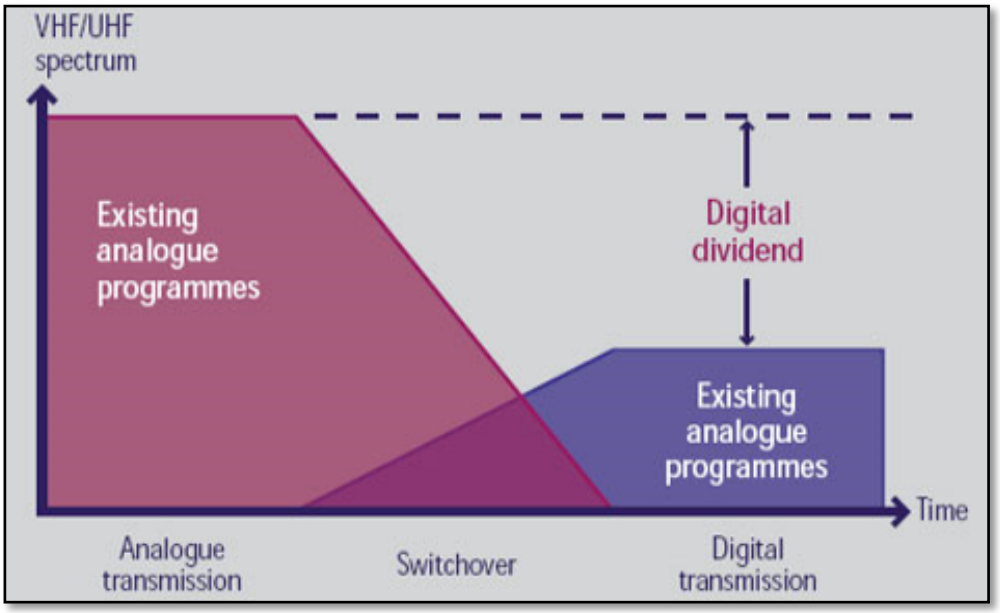

Figure 12. Digital dividend spectrum

Source: ITU (2010). ITU NEWS, *The digital dividend. Opportunities and challenges* (accessed May 2013), http://www.itu.int/net/itunews/issues/2010/01/27.aspx.

The importance of the digital dividend

It is important to fully understand the revolutionary impact of the digital dividend, which has been destabilizing the existing radio spectrum usage. It is worth noting that the digital dividend is part of the spectrum located between 200 MHz and 1 GHz, which is considered the most valuable part of the entire radio spectrum worldwide. It offers an attractive balance between transmission capacity and geographic coverage, which makes it suitable for a wide range of different uses. Keeping in mind this precious combination of key features, it can be easily understood why it is extremely rare to find unused UHF frequencies. Therefore, the digital dividend, which is a fairly large portion of the UHF spectrum, represents an once-in-a-lifetime opportunity to boost the growth of the ICT sector and a golden chance to meet the exponential demand for spectrum fuelled by mobile communications, by means of a more efficient use of the radio spectrum.

The allocation of the digital dividend is without any doubt an international issue. First of all because cross-border frequency coordination, where countries jointly agree on the same use of certain frequencies, is needed in order to avoid harmful interference with would impede the effective use of the spectrum by each country. In fact, radio emissions are not confined by national borders, as in their propagation, waves do not recognise boundaries, so they can cross frontiers and cause unwelcome interference. Moreover, a worldwide frequency harmonisation of the digital dividend usage would create enormous social and economic benefits for the mobile industry, the consumers and thus the whole economy.

At the international level, the use of the radio-frequency spectrum is managed and coordinated by the International Telecommunication Union (ITU). Within the international framework defined by ITU, each country is entitled to manage the radio spectrum according to national interests. However, although allocating the digital dividend falls ultimately within national prerogatives, regional organisations stand between the international and national layers. The role played by regional organisations is related to the convention introduced by ITU to divide the world into three Regions: Europe, Africa, the Middle East and northern part of Asia are included in Region 1; the Americas and some of the eastern pacific islands constitute Region 2; the southern part of Asia and Oceania are comprised in Region 3. The current trend shows a greater centralisation of spectrum decisions moving from national to regional level, in particular in Europe.

With specific regard to the digital dividend issue, in 2007 the ITU decided to allocate the upper part of the UHF band, released by the digital switchover, to the mobile service on a co-primary basis with terrestrial television. The allocation has been done, in each Region, as follows:

- 698-806 MHz band in Region 2 and nine countries in Region 3 (Bangladesh, China, Korea, India, Japan, New Zealand, Papua New Guinea, Philippines and Singapore);
- 790-862 MHz band in Region 1 and Region 3.

Within this new framework, national Spectrum Management Authorities (SMAs) have the freedom to choose which service should use the digital dividend, under the condition of bilateral or multilateral agreements with neighbouring countries about the selected use, in order to manage interference problems. Even though the allocation of those frequencies to mobile service is not compulsory, the growing importance of mobile service for both developed and developing countries is self-evident, given the widespread use of mobile applications and their undeniable positive social and economic benefits. Preserving the status quo would mean denying the progress made in the telecommunication sector and turning down the potential that advancements in mobile communication technologies can offer for a more efficient use of the spectrum and, thus, for the benefit of the whole society.

Obviously, SMAs will have to face broadcasters' opposition. In fact, they would be deprived of some spectrum frequencies historically used for television broadcasting, while they are eager to broadcast more channels in digital form. Moreover, SMAs need to settle new agreements with neighbouring countries in order to provide mobile services, while ensuring that interference problems will not arise. This negotiating process will profoundly modify the existing digital broadcasting plan, in particular in Region 1.

Moreover, in 2012, the ITU expanded the digital dividend including the 694-790 MHz band, in ITU Region 1, which will host both television broadcasting and mobile service on a co-primary basis from 2016. Focusing on Region 1, reallocating the 694-790 MHz band for mobile service will be significantly more disruptive to terrestrial broadcasters than it is in the 790-862 MHz band. In fact, terrestrial broadcasters would lose 30% of the total remaining UHF television spectrum. Such a reallocation cannot be seen as a release of frequencies thanks to technology improvements, but it is clearly a forced reduction of broadcasting capacity. In addition, significant planning and coordination among neighbouring countries will be needed in order to preserve equitable access to spectrum and control interference, as freeing up the 694-790 MHz band from television broadcasting will severely interfere with the existing spectrum rights of each individual country.

As matters stand, the challenge posed by the reallocation of the 694-790 MHz band should not be underestimated. A lot of interests are at stake. On one side mobile operators are starving for more spectrum, being the just released 790-862 MHz band not enough for the deployment of their services. On the other side, television broadcasters will find themselves in a situation extremely difficult to handle, as many DTT systems have already been re-planned to free up the first digital dividend. Moreover, the 694-790 MHz band is seen as vital for the future development of digital broadcasting technologies, which would be prevented if more spectrum was released.

Despite the availability of other platforms, such as the Internet, cable and satellite, DTT is the primary means of delivering television in many European countries and in most of them there is evidence of demand for additional DTT services. However, the role broadband services are playing for the economy worldwide cannot be

ignored, as well as the exponential increase in the volume of data traffic, which is growing even faster than predicted and will keep growing over the next years. As time passes, the true scale of the mobile phenomenon is becoming ever clearer.

While SMAs around the world are still working to re-farm the 790-862 MHz band for mobile service, countries in Region 1 and in particular EU Member States are setting the stage to face another challenge, harder than the previous one, regarding the 700 MHz band. In Europe, DTT is the dominant delivery platform for television with over than 275 million people watching television over DTT. Moreover, television broadcasting is widely considered as a crucial instrument in society for providing information and promoting shared values.

Europe has been working hard to structure a harmonised regional plan on the digital dividend, promoting coordination in the management and use of the spectrum, to be followed by all EU Member States. The aim is to put Europe in the condition to maximise the benefits that can be gained from coordinated pan-European services and markets. If spectrum harmonisation is not reached, Europe will have to face many negative consequences, such as cross-border interferences and impossibility for producers to build economies of scale due to fragmented national approaches, which will impede the development of a single European digital market.

A communication from the European Commission (EC) to the European Parliament (EP) states that the total value of services that depend on the use of the radio spectrum in the EU exceeds €250 billion annually, which is about 2.2% of the annual European GDP. It has been estimated that, in Europe, the wireless electronic communications industry supports 3.5 million jobs and generates around €130 billion annually in tax revenues. Moreover, mobile services have a penetration rate of 124%, being used by 83% of the EU households, which have access to at least one mobile phone, while 24% of households do not have access to a fixed line, they just rely on mobile devices.

In order to understand the social and economic impact of the potential uses that can be made of the digital dividend, the EU has been conducting a large-scale study, launched in 2008. According to this study, appropriate European coordination would increase the potential economic impact of the digital dividend by an additional €20 to €50 billion by 2015, as compared to individual EU Member States plans, depending mostly on the actual level of future demand for services such as advanced terrestrial broadcasting and wireless broadband services.

In the longer term, beyond 2015, further benefits of €30 billion could be realised through continued EU coordination. Evidence suggests that there would also be overall positive social benefits, albeit more difficult to quantify.

While there is wide agreement on the need for more spectrum for the development of wireless technologies, Europe will have to face many obstacles in pursuing its objective of a harmonised spectrum usage across its territory. EU Member States differ from each other in terms of internal specific conditions, such as geography configuration, political situation and spectrum management history. Europe's common policy must balance the needs of developing mobile broadband services

and, at the same time, the interests of existing spectrum users in a fragmented and uneven context.
Europe should accurately arm itself for the forthcoming World Radiocommunication Conference that will be held in 2015 (WRC-15), enhancing its role in order to ensure that all EU Member States will share European longer-term view on the future use of the spectrum.
SMAs, regional organisations, experts, broadcasting and mobile service operators and the whole ICT sector are looking forward to further international developments, which will occur in 2015. Decisions will be taken regarding the future use of the radio spectrum, which will inevitably mark the future path of the services and technologies involved.

Implications for future research

It should be quite clear that radio spectrum is an extremely valuable scarce resource for which demand is growing quickly along with the rise of innovative services, such as mobile broadband.
Mobile Internet is considered a disruptive technology, given its potential to transform life, business and the global economy, giving rise to new ways of understand, perceive and interact with and within the world. Mobile Internet technologies are rapidly advancing and experiencing everyday breakthroughs.
Even though the use of the Internet is already widespread, its scope of impact is even broader and not yet realised. However the economic and social benefits of mobile Internet usage may not be fully reached if sufficient spectrum capacity cannot be made available.
The allocation of the first digital dividend to mobile service has been one of the most relevant events that has revolutionised spectrum management worldwide. Nowadays, countries included in ITU Region 1 are setting the stage to face another challenge: that of the reallocation of the second digital dividend. Moreover, the international wish is to identify additional spectrum to be allocated for the mobile service, in order to facilitate the development of terrestrial mobile broadband applications. The question now arising is: how can additional spectrum be freed up for mobile services?
The Federal Communication Commission (FCC), the US telecommunications regulatory agency, which regulates interstate and international communications by radio, television, wire, satellite and cable, recognises incentive auctions as an innovative means to face the problem of spectrum need for mobile services.
An incentive auction is a market-based mechanism to clear incumbent spectrum licensees and assign new licences. The idea underlying this type of auction is encouraging existing broadcast television licensees to give up spectrum usage rights on a voluntary basis in exchange for a share of the proceeds from an auction of new licences to use the freed-up spectrum.

The auction is seen as a significant financial opportunity for many broadcasters, which could thereby have the means to invest in the development of new television technologies for a more efficient use of the spectrum. At the same time the released spectrum could be used for deploying mobile broadband.
The FCC structured the incentive auction in three interdependent parts:

- a "reverse auction" by means of which broadcasters decide their prices to voluntarily relinquish spectrum rights in exchange for payments;
- a "repacking" of the broadcast television bands, which involves reorganising and assigning channels to the remaining broadcast television stations still on the air in order to release frequencies in the UHF spectrum to be allocated to the mobile service;
- a "forward" auction of the amount of spectrum made available as a result of the two previous sections where potential users can compete for new initial licences.

The US is a pioneer in this field as its broadcast television spectrum incentive auction has been the first attempt worldwide, whose proceeding was launched by the FCC in October 2012. Moreover, its unprecedented structure makes the above incentive auction the first two-sided spectrum incentive auction in the entire world.
The uniqueness and complexity of this process instill several doubt regarding its feasibility and success. For instance, the number of broadcasters that will participate and the amount of spectrum that will be freed-up are uncertain. Moreover there are concerns related to the auction methodology and the impact on existing broadcasting stations which will choose not to take part in the auction, for example in terms of interference problems and reduction of coverage areas and population served. The way the released spectrum will be valued and the broadcasters' compensations will be determined are difficult to determine as well.
It will be interesting to follow the development of this process, which must be concluded by 2022 by Statute. Therefore, it would be quite challenging to investigate the possibility of an incentive auction in Europe, bearing in mind that, among other issues, in contrast to the US, in many European countries, DTT is the primary means of delivering television and there is evidence of demand for additional DTT services despite the availability of other platforms, such as the Internet, cable and satellite.
In order to meet the increasing demand for mobile broadband, the FCC is also working on spectrum sharing models. The same path is followed by Europe. In fact, the recent mandate issued to CEPT (European Conference of Postal and Telecommunications Administrations) by the EC also aims at studying the possibility of shared spectrum use between mobile broadband and other incumbent uses. The considerable growth of spectrum demand for mobile broadband has unveiled the impossibility for the available spectrum to meet the needs of future technologies. This calls for a change in the spectrum management to create a dynamic and flexible use of the spectrum. In this respect, spectrum sharing offers a potential solution to

addressing the problem of spectrum scarcity, maximising the use of under-utilised bands.

New and smarter technologies allow overcoming the interference problem, eliminating the necessity of assigning channels to specific users, as more applications may be able to share the same spectrum band. For instance, Cognitive Radio (CR) systems may be able to continuously monitor and detect unused spectrum potions, dynamically use free parts of spectrum and timely release them when a primary user starts to transmit on those frequencies. Therefore, spectrum policy reforms need to be implemented in order to introduce new forms of spectrum sharing, in particular in terms of usage rights.

There is a lot of scepticism regarding the effective potential of spectrum sharing, as related technologies still exist in embryonic form, which makes their performances uncertain, and long-term investments are required for governments and industries. Moreover, more coordination will be needed between services. However, given the fact that spectrum demand for mobile services is expected to grow in the future (under a mid-level growth scenario, mobile data capacity demand will experience an 80 fold increase between 2012 and 2030, and a 300 fold increase under a high-growth scenario), implementing dynamic spectrum sharing approaches could be seen as a successful long-term strategy.

An ambitious goal would be answering the question why dynamic spectrum management is a promising and viable solution to the spectrum scarcity problem and how spectrum management can be reformed in order to promote the adoption of dynamic spectrum sharing technologies.

Maybe, the time has come to architect a new plan from the foundations for the allocation of the UHF band although such a drastic approach would carry a higher degree of uncertainty. In the years ahead the importance of the mobile service and in particular of mobile broadband will continue to growth along with hungry for spectrum frequencies. Technological progress is inevitable, which need to be backed in order to reap its benefits.

It is still too early to predict how this extremely critical issue will end up. The final agreement resulting from WRC-15 will inevitably mark the future use of the radio spectrum and the technological development in particular of the mobile and the broadcast sector.

The aim

The main purpose of the present thesis is to retrace the primary stages that have marked the evolution of the digital dividend issue. Nevertheless, the aim is to start early on, from a bit of history regarding the development of electromagnetic theory and the studies on radio waves, trying to gradually give the reader, which is not into this field, all the tools necessary to understand how events took place and why certain decisions were made, in particular in Europe. For this reason the thesis is organised as follows.

Chapter 2 starts with a brief historical background regarding the development of electromagnetic theory. Then, the concepts of electromagnetic spectrum and radio spectrum are defined. With regard to radio spectrum, both technical and economic aspects are described.
Chapter 3 investigates the spectrum management issue in its three geographical layers: international, regional and national. The concepts of spectrum allocation and assignment are defined and, focusing on the national level, the main spectrum assignment approaches are broadly described.
Chapter 4 contains some data related to the recent developments in the ICT industry, in particular regarding the mobile service, whose widespread adoption calls for reforms in the spectrum assignment procedures. Thus, the main proposals seeking to define a renewed framework, distinguished in technology-driven and market-driven methods, are outlined.
Chapter 5 introduces the concept of digital dividend, trying to explain its origins and its main characteristics. Then, the chapter focuses on the potential uses of the digital dividend, supporting the rationale of an allocation in favour of the mobile service.
Chapter 6 starts illustrating the debate on the digital dividend issue. In particular, the chapter deals with the international main events which have led to the transition from analogue to digital terrestrial broadcasting, the allocation of the digital dividend to mobile services and further developments regarding the goal of extending the digital dividend in order to release additional spectrum to mobile service.
Chapter 7 focuses on the European approach towards the digital dividend, meaning that only the international decisions regarding Region 1 and the European actions on the digital dividend are taken into account.
The awareness of the immense scope of the issue addressed has led to the decision to concentrate mainly on one Region, Region 1, and, in more detail, on Europe. Choosing a Region would have been ensured a certain degree of consistency in the exposition, given that international actions are Regional-oriented, unless global decisions are taken. Moreover, the chapter lays stress on Europe, for the same reason stated above, meaning for a need for uniformity in the exposition, but also because it is believed that the high degree of diversity among countries, the long tradition of terrestrial broadcasting service, the existing use of radio spectrum and other aspects that characterise Europe would have made the thesis more interesting.
Chapter 8 calls attention to the national level. Specifically, two cases studies are shown with the aim to briefly describe the different approaches adopted in the United Kingdom (UK) and in Italy to face the digital dividend issue.
A Conclusive Chapter 9 encourages further research, which may be conducted regarding the necessity to meet the growing demand for spectrum fuelled by mobile broadband in a context of spectrum scarcity. In particular, the Chapter hints at the decision of the Federal Communication Commission (FCC), the United States (US) telecommunications regulatory agency, to adopt an innovative procedure termed "incentive auction". It aims at encouraging existing broadcast television licensees to give up spectrum usage rights on a voluntary basis in exchange for a share of the

proceeds from an auction of new licences to use the freed-up spectrum in the UHF band. The question is whether or not such a means can be implemented in Europe and how. Moreover, the Chapter refers to the on-going study on sharing spectrum in Europe and calls attention on the necessity to clearly understand why spectrum sharing is a feasible solution to the spectrum scarcity problem.

Methodology

In order to develop the thesis, an extensive desk research is conducted, which refers to the collection and examination of secondary data. The Internet is the main research tool. As secondary data are not all of the same quality in terms of authenticity and credibility, the purpose is to mainly rely on official documents, which can be considered more reliable than non-official documents. In this respect, most of the data are sourced from official websites and on-line archives of: the International Telecommunication Union (ITU); the European Union (EU); the European Commission (EC); the European Conference of Postal and Telecommunications Administrations (CEPT); the Radio Spectrum Policy Group (RSPG); the UK Office of Communications (Ofcom); the Italian Communications Regulatory Authority (Agcom).

ITU reports, articles, official documents related to the Regional Radiocommunication Conference held in 2006 (RRC-06), the World Radiocommunication Conferences held in 2007 (WRC-07) and 2012 (WRC-12) and the upcoming WRC-15, have been investigated.

As regards Europe, data are primarily sourced from: CEPT reports, released as result of the mandates placed by the EC; RSPG opinions; EC decisions, communications and recommendations; decisions of the European Parliament (EP) and the Council of the European Union, which are judged as relevant for the purpose of the thesis.

Consultations, regulatory statements and associated documents published by Ofcom are not only used for the development of Chapter 8, but their contributions add greatly to the structure of the entire thesis, being judged as well-developed and highly explanatory. Agcom resolutions, regulations and press releases, along with some specific Italian laws are used just for shaping Chapter 8. Given the peculiarity of Italian television market, the newsletter of Federazione Radio Televisioni (FRT), a federation representing Italian broadcasting operators, is largely used.

Moreover, the PolicyTracker spectrum management newsletter, the Telecommunications Policy Journal and IEEEXplore digital library represent cardinal sources of data.

Delimitations

The purpose of the thesis is to illustrate the main events which have determined the evolutionary path of the digital dividend issue, from an international, European and national point of view. The exposition does not go deep into facts, but aims at displaying prominently the principal decisions and related consequences so as to be

easily understood. Neither solutions nor predictions for future courses of actions are provided, although some considerations may have been expressed. Policy actions are not evaluated in a positive or negative sense; the aim is to call attention to results and effects of these policy interventions. Moreover, the thesis fails to proper investigate facts from a broadcasting point of view, emphasizing the mobile perspective.

Focusing on Europe, connections with African and Arab countries included in Region 1 are missing, as well as linkages to Region 2 and Region 3. A comparative analysis would be interesting as a better understanding of the reasons of certain decisions and of the origins of certain problems could be obtained.

In Chapter 8 the comparison between the UK and Italy purposes to show how national peculiarities such as geography, culture, political aspects and the level of development of certain technologies, may strongly impact on the way countries approach the digital dividend issue, although both countries are under the EU umbrella. No specific methods of investigation are applied.

In order to develop the thesis neither quantitative methodologies nor mathematical models are used, even though some remarks are supported by statistical data. The thesis limits itself to showing the results of a process of collection, organisation, analysis and synthesis of research material.