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On the Spectrum Market Value as Production Factor for Smart Technologies

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Abstract

The basic and required production factor for wireless communication technologies is the radio spectrum. Using the radio spectrum for different technologies, industries or services is regulated/managed by ITU at international level and by national authorities at national or state level. The paper deals with the valuation of radio spectrum as the scarce resource for the information society as well as for spectrum market pricing. Each smart wireless solution also intelligent transport systems and technologies needs the spectrum but it is necessary to know his value or price. They determine the costs of solution as well as the accessibility of technologies. Several procedures and models are used to estimate the value of radio spectrum. They vary in a different rate depending on the complexity of information including the time dimension which is required in processing. At the same time their application is determined by the subject that estimates the value, i.e. national regulatory authority or operator. The regulatory authority and operators have the different information about technology, market, cost etc. e.g. information asymmetry is significant in this area. The results obtained on the ground of the application of benchmarking and results of analysis of 281 auctions in selected EU countries are presented in submitted contribution.

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Keywords: benchmarking, pricing, auction, radio spectrum

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1. Introduction

Radio spectrum is the part of the electromagnetic spectrum from 8.3 kHz to 3000 GHz allocated to 40 Radio communication services in line to the Radio Regulations (RR) of the International Telecommunications Union (ITU) [1]. It is an essential input to all wireless services, with major contribution to economic and social development. These spectrum-based services includes mobile communications (such as cell phones and mobile broadband), fixed communications (such as broadcasting and wireless data links), and detection applications (such as radar) [2]. It is a natural, renewable and often scarce resource (especially below 1 GHz), which means its offer is limited [3]. Since radio spectrum is scarce the National Regulatory Authorities (NRAs) have to assign this resource wisely; in the most cases* NRAs represent the supply-side of radio spectrum market. With the constant rapid growth of mobile communications services such as wireless data services and increasing data consumption radio spectrum becomes more and more valuable. Spectrum is no longer associated with abstract technology but is more and more regarded as a valuable resource in our information society [4].

Appropriate spectrum values and price helps to promote spectrum efficiency. Market reveals the price of spectrum in the process of awarding the licenses to service providers. Price emerges through an authentic market transaction such as an auction or secondary trading. One of the most used approaches which can help examine the value of spectrum is benchmark. But is it a good indicator of spectrum market price?

In the present paper we shall attempt to analyze the results of more than 280 spectrum auctions, including bands suitable for 3G and 4G wireless services, to find out how benchmark can help to determine the market price of spectrum.

2. Theoretical background

To search the value of radio spectrum, we need to understand the nature of its value. Theoretical basis for spectrum value says it is not inherently valuable; rather its value derives from its use in deploying wireless services. As the profitability of spectrum-based services increases, the value of deployable spectrum assets also increases [2]. Hence spectrum valuation is neither static nor a set science, but it is kinetic [5].

To estimate the value of radio spectrum several procedures and models are used. They vary in a different rate depending on the complexity of information which is required in processing. Every model has its strengths and weaknesses. To subsequent determination of the price we need the market. There is no price without the market as well as there is no value without a (subjective) valuator. The market looks for the price and creates the market price.

However, we should have in mind that financial experts show us that there are few misconceptions about valuation. One of them says that valuation is an objective search for “true” value. There is nothing like true value since all valuations are biased [6]. Radio spectrum market have two sides – governments and their agencies (NRAs), which are responsible for spectrum allocation and mobile operators which want to satisfy consumer demand for telecommunications and radio spectrum is crucial input for their business. Both parties attempt to estimate the value of spectrum while mobile operators have considerable information advantage over NRAs. As NRAs act as regulators, the market reveals a significant information asymmetry and the principles of free market cannot be applied to spectrum [10, 12].

However, some of the principles of radio spectrum management have changed in the last two decades and with the launch of first spectrum auction in New Zealand (1996) many governments have gradually employed auctions in the process of awarding spectrum licenses. Key findings say that auctions employ a price mechanism to allocate spectrum and can be used to increase efficiency and revenue maximization [7, 11]. As long as the “seller” of spectrum license is also the regulator (except the case of Secondary markets) there cannot exist efficient market. Auctions allow market mechanism to get involved into the pricing process and the final prices of spectrum paid by operators are market-based. In an efficient market, the market price is the best estimate of value. The purpose of any valuation model is then the justification of this value [6].

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* In some countries radio spectrum can be traded in secondary markets. Usage rights can be shift from low-value uses to higher value uses.

Data collected through market transactions such as auctions might reflect market price of spectrum more than price information through beauty contests that include more characteristics related to licenses for example related to social responsibility. Hence, they can be used as data base in the process of benchmarking, which helps to review and estimate the value of spectrum.

3. Data and methodology

To estimate the value of spectrum it is possible to effectively use the procedure of benchmarking. Benchmarking means: we learn from the best, or we compare with the best and we learn from them. It is a specific process of processing information. It can also be interpreted as an orientation or comparative value on selected indicators or system, eventually for an evaluation of objectives. Benchmarking is the right method of search, finding and optimal use of new forms and ways enabling an increase of performance. The results of benchmarking are transparent and they can be used in appraisal towards the customers, competitors or external businesses in given area [8, 10].

The advantage of benchmark is that it uses real market data for analysis, as markets in different countries reveal the value of spectrum through the prices of other spectrum that has been auctioned. On the other hand prices can vary according to:

- Time: auctions can be held in different date range;
- Geography: local economic, competitive and demographic circumstances;
- Frequency: the frequency range and the size of the blocks sold;
- Type of service: the technologies and services that can use the band.

A simple benchmark cannot take control of all of these factors, but can reduce the impact of some inputs. There are no precise valuations, as all valuations are biased and simpler valuation models can do much better than complex ones [6]. At least benchmark can help us to make an overview of spectrum values through different countries.

4. Analysis of data

In the first step of analysis data collection is based on parameters suitable for benchmark. Source of data is DotEcon Spectrum Award Database [14]. Data base includes spectrum awards in the EU28, from the year 2010 onwards, including bands suitable for 3G and/or 4G, although our focus is on frequency bands used for 4G in Slovakia, respectively – 800 MHz, 1800 MHz and 2600 MHz.

We compare the results of benchmarking to results of Slovakia auction in 2013. Hence start date of data is in 2010, when the first 4G auction was held in Germany. End date of data is in 2013 when the 4G auction launched in Slovakia. Complete data base is described in Table 1.

Table 1. Benchmark Data Base Categories.

Parameter	Description	Specification
Type of awarding the license	Auction	281 samples
Country	Country	21 EU countries
Date	The end date of the award.	2010–2013
License duration	The term of the license in years. This can be expressed as a decimal to reflect non-whole years.	10–25
Spectrum band	Frequency band corresponding to the license.	800, 900, 2100, 1800, 2600 MHz
Spectrum width	Total amount of spectrum in MHz of the license.	paired + unpaired spectrum
Lot price	License price for spectrum won in the frequency band. This is the 'headline' price in local currency and may not include any annual fees over the term of the license plus any other fees e.g. administrative fees.	in local currency
Local Currency	Local Currency	11 different currencies

Source of Data: DotEcon Spectrum Award Database [14].

Please note, that data only includes the results for countries where auctions were held for individual spectrum bands and not as combinations of bundle of frequencies.

The process of benchmarking was done in six steps, which are described in Table 2. The prices of spectrum (lot price) from auctions have been modified according key parameters, because samples in spectrum auction database differ in spectrum width, license duration and population every country have. The discounting factor used for adjusting license duration is average weighted average cost of capital (WACC) of three Slovak mobile operators.

Table 2. The process of benchmarking.

Key Parameter	Price	Unit
Spectrum width	Price per MHz	Local Currency
License duration	Price adjusting for license duration – using WACC; 15 years – duration of the license to which the price is converted	Local Currency
Population	Price per MHz per capita	Local Currency
PPP LCU/USD FX	Price adjusting for purchasing power parity	USD
Cumulative US CPI	Price adjusting for inflation	USD
PPP LCU/USD FX Slovakia	Final price	€

Source of Data: Eurostat; World Bank's World Development Indicators; Bureau of Labor Statistics of United States.

As calculated prices per MHz per capita are in local currencies and the level of economic differ between countries, to ensure comparability prices are adjusted for Purchasing Power Parity (PPP). PPP conversion factor is the number of units of a local country's currency unit (LCU) required for buying of the same amounts of goods and services in the domestic market as U.S. dollar would buy in the United States. Prices are then adjusted for inflation using Consumer Price Index (CPI) since auctions were held in different years. In the final step the inflation-adjusted prices are converted into € using PPP FX rate. Final prices represent an estimation of market value of spectrum.

Final prices however do not reflect different countries specifics. Hence additional adjustment in form of weights is introduced into the benchmark process to be able to calculate the weighted average of prices. For each country relative weights are based on the relative difference between the country of auction and Slovak republic; taking into account the year in which the auction was held. Key parameters used for calculation of weighted average price are in the Table 3. The weights in the model give higher weight to countries with lower relative difference of each indicator and vice versa. The weights are in the range from 1 to 5.

Table 3. The process of benchmarking – weighted average price.

Key Parameter	Indicator of	Unit
Total Area	the relative physical size of the network	km^2
Density	the relative population density of the market	capita per km^2
Rural population	the relative cost effectiveness of the network	% of total population
Mobile penetration	the relative potential of the market	mobile cellular subscriptions per 100 inhabitants
Broadband penetration	the relative maturity of the market represented by the development of data services	mobile broadband subscriptions per 100 inhabitants
Economic Power	the relative overall economic development of the market	GDP per capita in PPP

Source of Data: World Bank's World Development Indicators; ITU, OECD.

In the process of statistical cleaning the final prices under 5^{th} percentile and above 95^{th} percentile were excluded. Results of final prices are presented in the next section.

5. Results

Prices of paired frequencies and unpaired frequencies vary through different frequencies and also in the range of same frequency – minimum and maximum price.

Calculated average prices and weighted average prices may seem to be only slightly different. In the term of 800 MHz there is 2% growth of weighted average price compared to average, and in the frequency bands 1800 MHz and 2600 MHz – paired and unpaired, –2%, +3% and –9% respectively. The difference may be better seemed, when the prices are calculated for real conditions of the country. As the prices are expressed in the form of 1 MHz per capita, after calculating the average and weighted average prices for the population of 5415949 (population of Slovak republic in December 2013) and for the spectrum width of 10 MHz (one block of spectrum in frequency band 800 MHz) the difference is almost 400000 €.

The prices vary also within the same frequency band and in 800 MHz maximum price reached in the band (Italy; 29.9.2011; 10 MHz) is 49% higher than minimum price (Lithuania; 11.10.2013; 10 MHz).

To see how the prices vary through the different countries we provide for example a chart overview of the frequency band 1800 MHz – paired (see Fig. 1).

Fig. 1. An overview of final prices – 1800 MHz.

Axis on the left side represents the market price of spectrum in 1 MHz per capita in € calculated in the process of benchmarking. Right minor axis represents the weighted average of a country. The results show the significant distribution of prices which can be caused by different level competition of markets, auction conditions, format of auctions and willingness to pay.

The process of calculating weighted average price revealed information about countries which have substantially economic and telecommunications conditions similar to Slovak republic according to key parameters have been taken into account (Table 3). The countries are as follows: Czech republic (weights – 4.2); Portugal (weights – 4.0) and Croatia (weights – 4.0). The countries with the lowest weights are: Finland (weights – 2.5); United Kingdom (weights – 2.6); Sweden (2.6). The lower the weights the higher relative difference between this country and Slovak republic. These countries have different level of maturity of the market with different local conditions in comparison to Slovak Republic.

If the results are split (average lot price – in MHz per capita in €) for three countries with the highest relative weights for frequency bands 800 MHz, 1800 MHz and 2600 MHz and compare to reserve prices set to 4G auction in Slovakia, we can notice relative proximity of prices. The best comparison however, would provide lot prices reached in Slovak republic, but radio spectrum were not auctioned for individual spectrum bands, therefore the price separately reached for these bands is not known.

Benchmark summary provides an overview of market spectrum value and can be helpful in the process of setting reserve prices. NRAs have to make an estimation of discounts to set reserve price for auctions. If reserve prices are set to high it may lead to low demand for the auction and in turn to low competition.

The analysis was made for all 281 auctions and the results are split by countries. The results suggest that 47.33% of all auctions reached the ratio between 90% and 100%. It means that the lot price is at the same level as reserve price in auction or the lot price is higher than reserve price in the range of 10%. The range of ratios is between 0.4% (Germany auction in 2010, band 800 MHz) to 100% (15 countries, different years and bands). This is the evidence of various methods used by regulators to set reserve prices.

Auction results can vary in line with the level of competitiveness, but there exists no clear correlation between the number of bidders and ratio of reserve price to lot price in auction (the correlation coefficient = – 0.22767).

The problem of setting prices however would require a more profound analysis.

6. Conclusions

Benchmarking process can provide very complex information about the market price of radio spectrum. The row data obtained from database or from publicly available data sources such as regulators websites or auction documentations have to be modified to reduce the impact of factors mentioned in the chapter 3.

Time differences between the years of auctions may have impact on spectrum market price, but adjustment on license duration and inflation can reduce a risk of currency fluctuation in time.

Geography differences involving national economic specifics and demographic circumstances between the countries may be reduced after adjusting the prices for purchasing power parity and demographic specifics are taken into consideration in the process of calculating weighted average price. Level of competition on telecommunication market however is not a part of calculation, and its impact on market spectrum price is not taken into account. Number of operators as indicator of relative competition on market can be an additional parameter in the process of calculating weighted average price.

Frequency differences as the frequency range and the size of block sold are modified in the first step of process of benchmark. Different level of demand for individual spectrum blocks even in the same frequency band may be caused by previous assignments to mobile operators in each country. It is not able to take this problem into account for each country of benchmark.

Differences in type's service and technologies may vary in accordance to frequency band but International Telecommunication Union encourages governments and regulators to allocate radio spectrum consistently in almost every geography for the same service – spectrum harmonization. Frequency bands used in our process of benchmark are internationally harmonized.

The market value of radio spectrum can be estimated through the benchmarking process.

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