International Journal of Economic Research

ISSN : 0972-9380

available at http: www.serialsjournals.com

Volume 14 • Number 15 (Part 4) • 2017

The Settlement of Compensation in Refarming of Telecommunication Spectrum: Case Study of the 2600 MHz Spectrum in Thailand

Rujirada Chaykaew[1] and Komsan Suriya[2]

[1]Faculty of Economics, Chiang Mai University, 239 Huaykaew Rd., T. Suthep, A. Muang, Chiang Mai 50200 Thailand. Email: amplono999@gmail.com

[2]Center of Excellence in Digital Socio-economy, Faculty of Economics, Chiang Mai University, 239 Huaykaew Rd., T. Suthep, A. Muang, Chiang Mai 50200 Thailand. Email: Suriya.goettingen@gmail.com

ABSTRACT

The main purpose of this paper is to calculate the appropriate compensation amount for the refarming of the 2600 MHz spectrum in Thailand. Because the spectrum is limited in terms of resources, there is a lack of spectrum coverage for all operators. Moreover, some bands of spectrum have not been used, making it useless and poor in terms of management. This problem can be solved by the National Broadcasting and Telecommunication Commission (NBTC) through spectrum refarming.

As current, the NBTC aims to further develop the country by expanding and improving network coverage from 4G to 5G. This enables people in the country to use a faster and better quality of Internet system. However, the NBTC needs to use a larger spectrum as part of the telecommunications infrastructure in order to fully develop 5G. Therefore, the NBTC has to conduct spectrum refarming and the NBTC has to be compensated for such spectrum refarming in respect of the fact that they currently hold this spectrum.

This research study focuses only on the 2600 MHz spectrum as this is the best possible spectrum that can be refarmed in the near future. Currently, the Mass Communication Organization of Thailand (MCOT) holds this spectrum. Moreover, the MCOT has some other spectrum bands that have not been used. Therefore, this research aims to calculate the compensation for the refarming of the 2600 MHz spectrum. In this regard, the NBTC has to compensate the MCOT for spectrum refarming.

There are two sides considered to be part of this research, namely the MCOT and the NBTC. This research implements two methods in order to calculate the compensation amount: the "benchmarking method" and "full enterprise method". The full enterprise method is applicable to the NBTC and the benchmarking method is applicable to the MCOT. This research uses data obtained from ITU to calculate the compensation figure.

A comparison is made between the data obtained from ITU and the data regarding the relative band value of the spectrum to find total revenue of 2600 MHz via the two methods. After the researcher has obtained a total revenue amount that has been calculated by using both methods, the researcher will then plot the value in a value line. After that, the researcher will look for an area of agreement between two sides.

From the result, this research focuses on the result of the total revenue from 2019. The result from the full enterprise method (or NBTC's side) concludes that the total revenue is at THB 1,288 million to 1,304 million. This means that the NBTC has the ability (i.e. necessary funding) to pay the compensation for spectrum refarming in the range of THB 1,288 million to 1,304 million. The result from the benchmarking method (or MCOT's side), concludes that the total revenue is at THB 765 million to 775 million. This means that the MCOT can agree and accept the compensation for spectrum refarming in range of THB 765 million to 775 million.

The result from this research, it is shown that the NBTC can successfully refarm the 2600 MHz spectrum from the MCOT. This is because the total revenue from the NBTC is higher than total revenue from the MCOT. Therefore, the NBTC and the MCOT are both satisfied with this outcome. The NBTC can agree on the compensation amount for the refarming of 2600 MHz with the MCOT at the total of THB 775 million. This is considered to be the area of agreement between the two sides. The results of this research can be used as a guideline for the projects of the NBTC for refarming 2600 MHz.

Keywords: Telecommunications; spectrum refarming; compensation; regulation; negotiation.

1. INTRODUCTION

Spectrum plays a very important role in telecommunications. It makes wireless telecommunications and mobile broadband Internet possible for everyday life. Telecom operators chase for both domestic and international spectrum to enhance their telecommunication services communication.

National Broadcasting and Telecommunication Commission (NBTC) needs more spectrum for National Broadcasting and Telecommunication Commission (NBTC) needs more spectrum for develop to 5G in future. It helps to more convenience for citizen in country. Such as it has more communicate and send data across countries.

Moreover, it helps to more export to other countries. Because foreign people more confident that our country have quick process to export product. It also helps people in countries have easier living. They will can more shopping online and pay many bills though Internet system. Because they trust Internet system in country is stable and high speed.

Therefore, it is evidence that people needs to use more and more high speed Internet. Because it helps people has more convenience and save time to do many activities in their life. So, this figure support project of NBTC for develop Internet to 5G.

It affects to users have quick communication and data transmission. It helps to develop countries such as it can push the country in the digital policies that government intends marked. It can increase growth of GDP more than apply to broadcasting.

NBTC needs 690 MHz of spectrum to develop telecommunication in 5G. But in the current, NBTC has only 250 MHz of spectrum. Therefore, the NBTC needs to use a larger spectrum as part of the telecommunications infrastructure in order to fully develop 5G.

However, the spectrum is limited in terms of resources, there is a lack of spectrum coverage for all operators. Such as private institution, government institution and citizen. Many operators want to hold spectrum. They can increase revenue from using spectrum. Because they use spectrum for create new services for consumers. They will get profit from holding more spectrum. Therefore, they have auction spectrum for a long time. It makes many operators bid spectrum among of operators for win to hold spectrum. It helps to manage spectrum among of operators fairly.

Moreover, some bands of spectrum have not been used, making it useless and poor in terms of management. Even though, operators try to use the spectrum for development in telecommunication. But they still have some spectrum leave for using. It effects to bandwidth of spectrum have not enough for demand of consumers. It effects to other operators need to hold spectrum but they loss in auction. They cannot to hold spectrum although the current holding some bands of spectrum have not been used.

This problem can be solved by the NBTC through spectrum refarming. Because NBTC needs more spectrum and the holder has some bands of spectrum have not been used, making it useless and poor in terms of management. It helps to improve effective using spectrum. It also helps to use spectrum which is limited in terms of resources efficiently.

Therefore, International Telecommunication Union (ITU) and NBTC consider spectrum refarming when spectrum has problem. It helps to develop telecommunication systems and generation of Internet to more effective for keep up with other countries.

In telecommunication, spectrum of 700 MHz, 2300 MHz and 2600 MHz suit for telecommunication. When NBTC can use these spectrum in telecommunication. The NBTC can further develop the country by expanding and improving network coverage from 4G to 5G. This enables people in the country to use a faster and better quality Internet system.

The situation of 700 MHz spectrum in Thailand, NBTC uses 700 MHz in the TV broadcast. The country have different opinion between operators for using 700 MHz. By many operators want to use 700 MHz in telecommunication more than use in TV broadcast. ITU suggests that if NBTC bring 700 MHz in telecommunication. It will helps to respond demand for using spectrum

The situation of 2300 MHz spectrum in Thailand, TOT holding maximum bandwidth of 2300 MHz in the current. They have bandwidth amount of 64 MHz. They holding this spectrum until 2025. However, TOT still use 2300 MHz less utility. Many operators begin to claim to 2300 MHz out bid instead of TOT holding a lot. While TOT negotiate with NBTC for return some spectrum to the NBTC, amount of 34 MHz.

The situation of 2600 MHz spectrum in Thailand, Mass Communication Organization of Thailand (MCOT) holds 2600 MHz in the current. But they use 2600 MHz less than the existing. By they have bandwidth amount of 144 MHz. Therefore, NBTC begin to reclaim some spectrum from MCOT to bid in the future. Because NBTC needs more spectrum for development 3G to 5G. NBTC wants to bring some spectrum from MCOT to more effective.

In situation of each spectrum in Thailand, researcher chooses 2600 MHz become to case study in this paper. Because 2600 MHz has possibility to achieve spectrum refarming and use a least time to process for spectrum refarming when compare with other spectrum.

MCOT holds 2600 MHz in the current, MCOT has some spectrum do not bring to use more than other spectrum. Moreover, MCOT uses this spectrum in broadcast and has low profit. It can reference from annual report of MCOT in 2016. MCOT loss 757.79 million THB in 2016.

NBTC can contract with MCOT about holding 2600 MHz easier than other spectrum. Because 700 MHz in Thailand, NBTC uses for broadcast and broadcast of NBTC necessity for the country. If they use 700 MHz in telecommunication, they have to bring other spectrum instead to 700 MHz for using in broadcast. Therefore, 2600 MHz has possibility more than 700 MHz.

Moreover, TOT uses 2300 MHz for primary responsibility about service in home phone and public telephone. They have a role for public telecommunication. Although TOT uses this spectrum less efficient, but they use this spectrum for public affairs in the countryside. Therefore, 2600 MHz has possibility more than 2300 MHz.

Therefore, researcher chooses 2600 MHz in Thailand become to case study in this paper. Because 2600 MHz has possibility to achieve spectrum refarming when compare with 700 MHz and 2300 MHz according to the situation of each spectrum in Thailand.

However, the NBTC has to compensate the MCOT for spectrum refarming. Because spectrum does not free value. So, NBTC cannot return spectrum from MCOT by pay nothing. NBTC has to compensate for MCOT by exchange spectrum with the compensation for spectrum refarming.

Other than, spectrum does not a private good in the market. It has not spectrum market in the country. It has not standard price like other good in the market. Therefore, spectrum needs to estimate value of spectrum.

However, NBTC has problem about how much the compensation that MCOT satisfies. Because NBTC does not know about actual perceived value of MCOT holding of the spectrum. So, the problem involves asymmetric information. If NBTC pays too low the compensation to MCOT. It makes MCOT rejects offer and no refarming. But, if NBTC pays too high the compensation to MCOT. MCOT accepts offer and occurs refarming. But, NBTC will overpay for refarming.

In summary, this study will calculate the compensation for spectrum refarming of the 2600 MHz. Some bands of the spectrum have not been used while NBTC needs more spectrum to develop 5G system of mobile phone service in Thailand. This problem can be solved by spectrum refarming.

However, the problem is how much the current holder of the spectrum should be satisfied. Both agents have asymmetric information about the perception of value of the spectrum. Therefore, this study will calculate the value which is closed to real value perceived by both agents.

Therefore, this study will calculate the compensation for the refarming of the 2600 MHz spectrum in Thailand, perform sensitivity analysis of the compensation, and suggest possible options of the compensation for the refarming of the 2600 MHz spectrum. To achieve this, this study will bring data from calculation of other spectrum in the past such as 1800 MHz and 2300 MHz from ITU to be references in the calculation. Ultimately, this study aims at bringing the spectrum to use in telecommunications effectively. It also helps the transition from 4G to 5G when NBTC compensate the refarming successfully.

2. THEORETICAL FRAMEWORK

This paper uses contract theory and asymmetric information to application on refarming. This paper has 2 players, players have NBTC and holder. This paper divides two sides in a graph which are the perceived value of spectrum of NBTC. This paper assumes NBTC to be player A and the perceived value of spectrum of holder, player B.

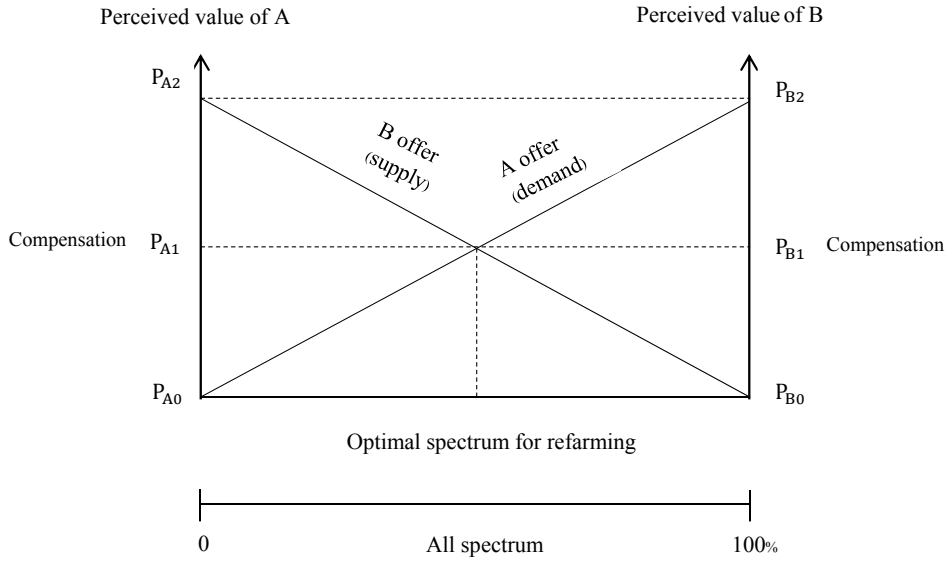

Figure 1: Perceived value of spectrum of NBTC and holder
Source: **Adaptation from Martin Cave (2016)**

On the side of player A:

If market has a few amount of spectrum, A will less perceived value at P_{A0}.

But if market has a lot of spectrum, A will more perceived value at P_{B2}.

Therefore, player A represents to demand curve.

On the side of player B:

If market has a lot of spectrum, B will less perceived value at P_{B0}.

But if market has a few amount of spectrum, B will more perceived value at P_{A2}.

Therefore, player B represents to supply curve.

When demand and supply curve intersect, it occurs optimal spectrum for refarming and compensation between player A and player B at P_{A1} and P_{B1}. Under Asymmetric Information, the actual perceived value of player B is unknown. Player B may has perceived value at upper bound or lower bound. But this paper knows only perceived value of player A. Because this paper works to help player A to compensate for player B. Therefore, this paper has player A under perceived value rationality.

This paper brings both sides under asymmetric information combine together. It occurs two equilibrium point at E_1 and E_2. It effects to occur problem about which equilibrium is the best to contract. If this paper use equilibrium point at E_2 but actual value occur at E_1. It makes player A overpay for refarming.

Therefore, this paper tries to find perceived value that close to actual perceived value as possible. This paper assumes C* and Q* are actual perceived value.

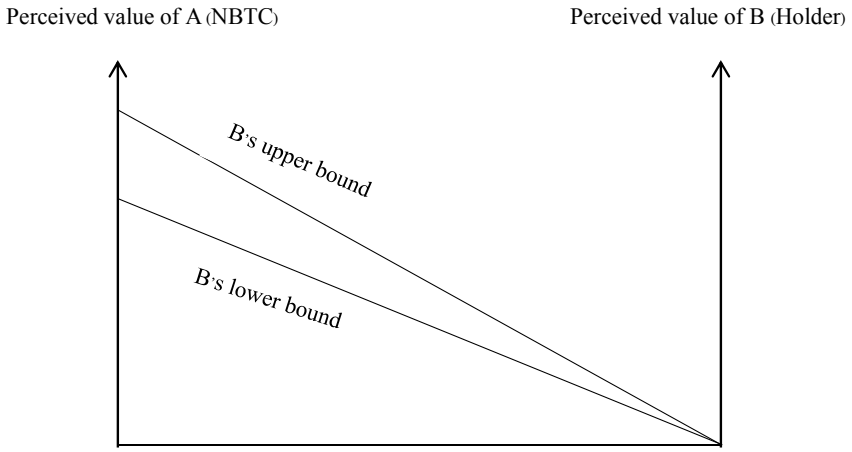

Figure 2: Perceived value of player B under asymmetric information
Source: **Adaptation from Martin Cave (2016)**

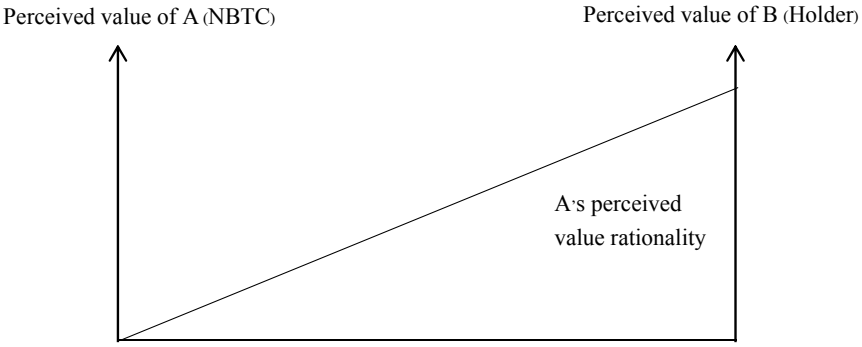

Figure 3: Perceived value of player A under perceived value rationality
Source: **Adaptation from Martin Cave (2016)**

At the result in this diagram, if player A offer $C_1 < C^*$, player B will refuse and no refarming. If player A offer $C_2 > C^*$, player B will accept but player A overpay for refarming. Therefore, accurate valuation of spectrum is needed. In conclusion: The refarming contract needs $C \geq C^*$.

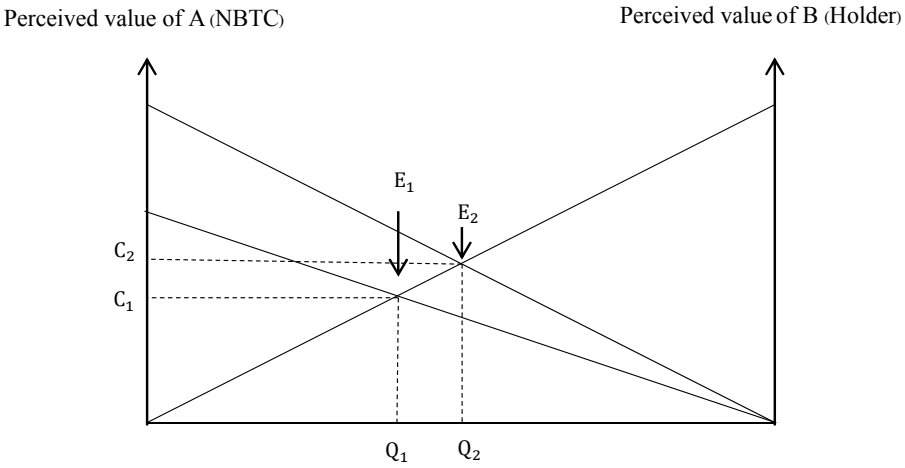

Figure 4: Equilibrium point of perceived value under asymmetric information
Source: **Adaptation from Martin Cave (2016)**

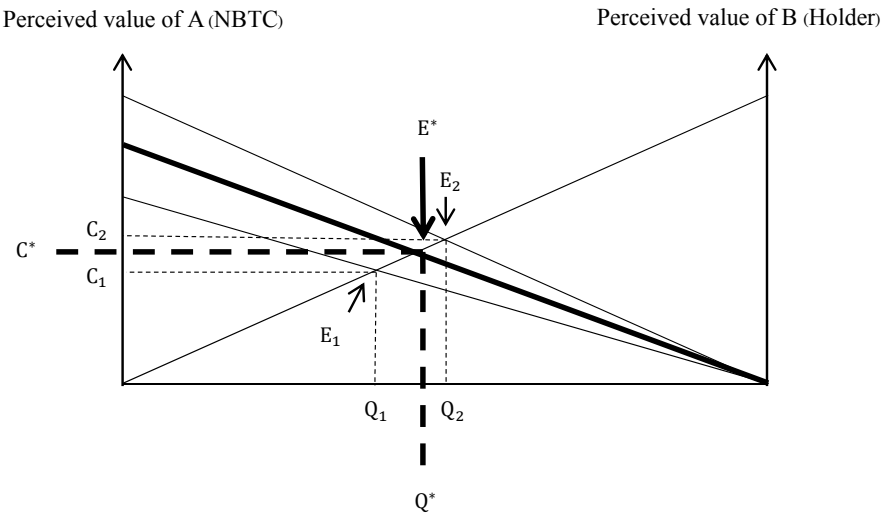

Figure 5: Equilibrium point of actual perceived value
Source: **Adaptation from Martin Cave (2016)**

3. LITERATURE REVIEW

Many countries adopt spectrum refarming, for example, France has spectrum refarming in 900 MHz and 1800 MHz. They begin to consider about spectrum refarming in 2001. In the year, they promote about develop 2G to 3G. They have spectrum refarming in 900 MHz before 1800 MHz. By they begin the project since 2008. They focus on three main operators in France. They renew license of spectrum and adjust regulation and policy about holding spectrum. It helps to redistribution between GSM and 3G operators fairly. During 2003-2009, they face on problem about spectrum refarming. They have problem about return spectrum from operators and obligation of the old holding spectrum of 2G. Therefore, they adopt obligation and move holding spectrum of 2G to 3G by renew license.

Moreover, they have plan for spectrum refarming 900 MHz. By they have two scenarios. They have case of having new entrant and case of none of new entrant. By case of none of new entrant, they assume everything remain no change. Case of having new entrant, they will change proportion of holding spectrum of three operators. By return spectrum 2×5 MHz each of three operations. They will give it for the fourth operators. In 2011, spectrum in 900 MHz has refarming complete and begin to spectrum refarming in 1800 MHz.

Other than that, in Ukraine, Guskov et. al., (2013) have spectrum refarming for deployment LTE networks by they want to improve effective of using spectrum. Other than, they want to improve effective of GSM system for increase utility of users GSM. They spectrum refarming in 900 MHz and 1800 MHz. These spectrums very important to develop GSM and LTE. Therefore, they bring these spectrums integrate with structure of GSM.

They use two models to refarming. The first, Gateway Core Network model (GWCN)which makes better interaction between network control and it helps to link other network to join. The second, Multi Operator Core Network (MOCN) which reduce traffic in network. In primary step, they use GWCN model but they want to change using MOCN to GWCN in the long term. The result found that this research achieves the goals that they set about development in LTE and GSM.

Lin and Viswanathan (2013) also want to spectrum refarming for development to LTE as Guskov et. al., (2013). They have purpose to solve this problem by bring GSM link and shared to inside of LTE system for it can overlay effectively, by reserve block network of GSM. After that, they will can spectrum refarming of 2G change to LTE effectively.

Moreover, they can share spectrum between GSM and LTE. Other than, they also offer to recover amount of loss LTE from overlay in GSM. Because the result found that loss LTE from overlay in GSM significant reduced with improvement proposed. So, this research focuses on overlay in GSM. They also focus on amount of loss LTE from overlay in GSM. Other than, they can adopt to overlay in other technology change to LTE.

For the valuation method, Plum Consulting (2011) calculates the renewal price of licenses by using cost reduction value and full enterprise method. Plum uses these methods to calculate value of license spectrum. Plum calculate in three scenarios. It consists of low, medium and high enhancement. Cost reduction value method consists of two variables. It has capacity enhancement and coverage enhancement. Plum assumes coverage enhancement constant in all scenarios. It can change only in capacity enhancement. In full enterprise method, Plum assumes that when increase ARPU growth, more full enterprise. By cost reduction does not change. When Plum gets data to calculate. Plum bring two methods above to calculate. By cost reduction sets to minimum value and full enterprise sets to maximum value. After that, Plum will get range of value for renewal price.

In side of Malisuwan et. al., (2015), they use same method of Plum Consulting (2011) at first. But in the second method, they use econometrics to calculate value of spectrum. They use econometrics to find relationship of spectrum value across countries. By reference value from the past auction in many countries. Then, they estimate value by two approaches. They have ordinary least square (OLS) and maximum likelihood. They will forecast spectrum value by replacing value that they determine into equation. They have opinion that the second method better than the first method. Because econometrics uses macro level data. They can get data easier than the first method. The first method uses micro level data and business data. It is difficult to get data to calculate.

Moreover, Malisuwan et. al., (2016)use benchmarking to calculate value of spectrum. Benchmarking has three approaches. It consists of absolute value, relative value and econometrics. They focus at absolute value to calculate value of 1800 MHz in Asia Pacific. Because they think that econometrics hard to estimate value of spectrum. Therefore. They use absolute value replace econometrics. Because it easier to calculate than econometrics. When they bring spectrum value from many countries. They will bring value to find average value. In case of Thailand, they found that Thailand have average value THB 10.51/MHz/pop (spot) and THB 7.25/MHz/pop (ppp). The spectrum value comes from absolute value method.

Therefore, when researcher reviews research papers above. Researcher found that almost of all papers have same purpose are they want to reallocate holding spectrum of operators for improve management and have more effective. But they study only about methods of spectrum refarming. They do not study about calculate compensation to operator that hold a spectrum. Because in the present, it does not clear about solve for compensation to operators. Therefore, researcher should study about value of spectrum refarming for compensation to operators.

4. COMPARE TOTAL REVENUE BETWEEN BENCHMARKING AND FULL ENTERPRISE

This research takes the total revenue from two scenarios that use the benchmarking (BM) and full enterprise (FE) method respectively; such results are plotted in the graph below.

Values from the full enterprise method fall into the range that the NBTC has the ability to pay regarding the compensation of the refarming of the spectrum. The values obtained from the benchmarking method fall into the range of values that the operator or the MCOT, in this paper, is willing to accept regarding the compensation amount for the refarming of the spectrum.

The result from this research shows that the full enterprise method contains a total revenue higher than the benchmarking method. This means that spectrum refarming of 2600 MHz between the NBTC and the MCOT is deemed as acceptable and, therefore, can be a successful part of the process of this project.

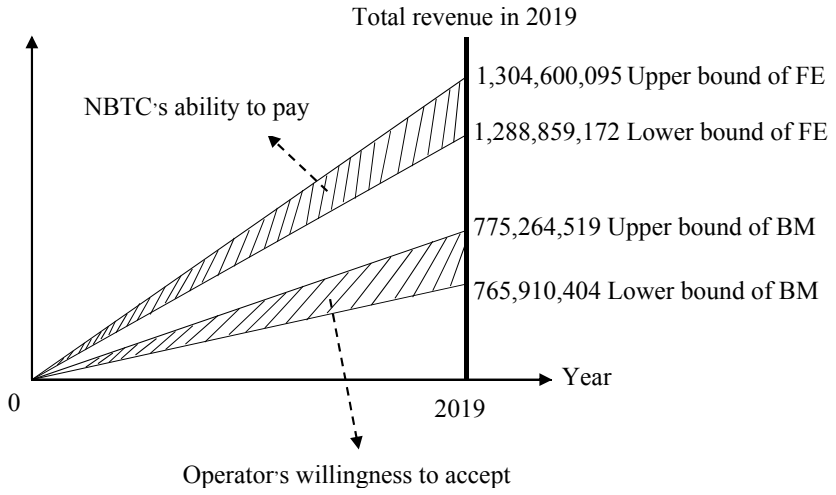

Figure 6: Comparison between the total revenue from benchmarking and full enterprise methods
Source: **Calculation based on this research.**

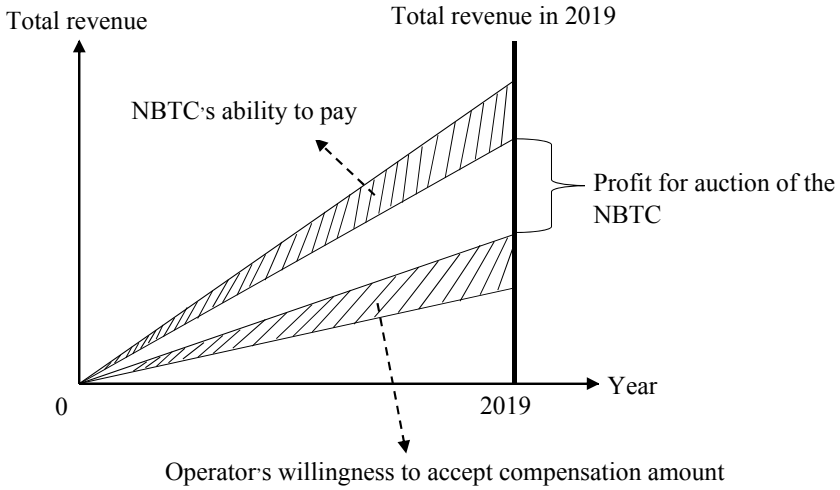

Figure 7: Value differences between full enterprise and benchmarking
Source: **Calculation based on this research.**

Furthermore, the value at the upper bound of benchmarking is the highest value that the MCOT is able to accept for paying the compensation amount of refarming. Therefore, the NBTC is able to agree upon a value of 2600 MHz with the MCOT at the upper bound of benchmarking which is THB 775,264,519.

In addition, the total revenue that the NBTC and the MCOT are able to accept for the compensation for the refarming of the spectrum is lower than the total revenue range that the NBTC has the ability and willingness to pay. Therefore, this causes differences in values between the total revenue for the compensation and the range of total revenue that the NBTC has the ability and willingness to pay. It is deemed as a profitable action for the NBTC to bring 2600 MHz to auction in the market.

5. CONCLUSION

The main purpose of this paper is to calculate the appropriate compensation amount for the refarming of the 2600 MHz spectrum in Thailand. Because the spectrum is limited in terms of resources, there is a lack of spectrum coverage for all operators. Moreover, some bands of spectrum have not been used, making it useless and poor in terms of management. This problem can be solved by the National Broadcasting and Telecommunication Commission (NBTC) through spectrum refarming. As current, the NBTC aims to further develop the county's network coverage from 4G to 5G. However, the NBTC needs to use a larger spectrum as part of the telecommunications infrastructure in order to fully develop 5G. Therefore, the NBTC has to conduct spectrum refarming and the NBTC has to be compensated for such spectrum refarming in respect of the fact that they currently hold this spectrum. This research study focused only on the 2600 MHz spectrum because the 2600 MHz spectrum is able to be successfully refarmed and takes the least time to be refarmed compared to other bands of spectrum.

Currently, the MCOT holds this 2600 MHz spectrum and, at the same time, hold other spectrum bands that are not as widely used. Moreover, the MCOT uses this spectrum for broadcast purposes and has a low profit. This can be referenced from the annual report of the MCOT in 2016 which shows losses in that year of THB 757 million. The NBTC can create a contract with the MCOT allowing them to hold the 2600 MHz spectrum much more easily than forming contracts to hold other spectrums. Because 700 MHz is in Thailand, the NBTC uses it for broadcasting and the broadcasting operations of the NBTC is regarded as a necessity for the country. If they use 700 MHz in telecommunications, they have to bring other spectrum bands instead of 700 MHz for using in broadcasting services. Therefore, 2600 MHz has a higher potential compared to700 MHz.

Moreover, TOT primarily uses 2300 MHz for as part of the service for home phones and public telephones. It can be said that they have a responsibility and role to play ensuring public telecommunication is maintained. Although TOT uses this spectrum less efficiently, it should also be considered that they also use this spectrum for public affairs in the countryside. Therefore, 2600 MHz has a higher potential compared to 2300 MHz.

Therefore, this research aims to calculate the appropriate compensation amount for the refarming of the 2600 MHz spectrum, as there is a necessity for the NBTC to compensate the MCOT for the spectrum refarming. In this light, it can be seen that there are two different sides in this research, namely, the MCOT and the NBTC. This paper uses two methods for the calculation of the appropriate amount of compensation; the benchmarking method and the full enterprise method. In general, for the calculation

of the spectrum there are actually three different methods; the benchmarking method, the cost reduction method and the full enterprise method. However, for this particular research, the researcher has omitted cost reduction method. The reason for this is because this method is calculated from the costs associated with operation. Therefore, the values obtained through using this method will be very low when compared to other methods, resulting in a range of values of 2600 MHz being too wide and therefore, inappropriate to use. Therefore, this research has implemented only methods for the calculation process; the benchmarking method and the full enterprise method.

The full enterprise method has a value of spectrum higher than that of the benchmarking method. This is because the full enterprise method is calculated based on revenue and profit from a business aspect, whereas the benchmarking method is calculated based on the average value from the auction in the past. In this case, where the calculation from the profit is higher than the average of the auction, it makes the full enterprise method to produce a higher value than the benchmarking method.

Therefore, this research assumes the full enterprise method for the calculation of the compensation amount for the NBTC side and the benchmarking method for the calculation of the compensation for the MCOT side. Due to the fact that the compensation of the NBTC side must be greater than the MCOT side, both sides must be able to agree upon an appropriate compensation amount for the spectrum refarming.

In the process of calculation, the researcher uses sets of data obtained from the ITU; value/MHz/pop for 2100 MHz benchmarks, which is used for the calculation process as part of the benchmarking method and the full enterprise modelling, which is used for the calculation process as part of the full enterprise method. The researcher will use both methods as part of the mathematical rule of three with relative values of spectrum data in order to find the final value of THB/MHz/pop for 2600 MHz.

After this process, the researcher uses THB/MHz/pop for 2600 MHz to predict the amount in the years 2016 – 2019. This is achieved by including inflation in each year to find the value of THB/MHz/pop for 2600 MHz in the years 2016 – 2019, with a unit of THB/MHz/pop.

After that, the researcher will change the unit of THB/MHz/pop to become a unit expressed in THB. This is done by including the number of people living in Thailand (the Thai population) in each year to find the total revenue of 2600 MHz, in units of THB.

It is worth noting that both methods have two different factors which have an influence on the value of 2600 MHz; these factors could cause the value of 2600 MHz to change. These factors consist of world inflation rate and Thai population growth rate.

Because the calculations of the values of the 2600 MHz are made throughout the years from 2016-2019, each year will exhibit a difference in value due to the varying time values of money and applicable currencies. Therefore, world inflation rates need to be considered as part of the calculation. Regarding the Thai population growth rate factor, this relates to the value of the 2600 MHz because of the unit of 2600 MHz. Because the unit of 2600 MHz is THB/MHz/pop, the value of 2600 MHz is on a per-person basis. Therefore, population growth rate must be considered.

This research creates a format for predicting the total revenue in 5 different scenarios P_1 to P_5. However, this research ultimately cut out scenarios P_3, P_4 and P_5 as P_1 and P_2 are deemed to be the most plausible amongst the defined five scenarios. Moreover, from the formula of P_1 and P_2, P_2 is seen to have a higher

potential in total revenue compared with that of P_1. Therefore, this research assumes P_2 as the upper bound of 2600 MHz in each method and assumes P_1 as the lower bound of 2600 MHz in each method.

As for the end results, this research focuses on the result of the total revenue from 2019, the result from the benchmarking method (or the MCOT side), is seen to have a total revenue at the lower bound of benchmarking equal to THB 765 million and upper bound of benchmarking equal to THB 775 million. This means that the MCOT is able to agree and accept the compensation amount for spectrum refarming in the range of THB 765 million to 775 million.

Therefore, the MCOT will agree with the compensation amount when it is not lower than the defined lower bound of benchmarking which is at THB 765 million. This is the minimum value of 2600 MHz that can be agreed and accepted by the MCOT for the compensation of the refarming of the 2600 MHz spectrum.

The result from the full enterprise method (or the NBTC side) is seen to have a total revenue at the lower bound of the full enterprise method equal to THB 1,288 million and the upper bound of the full enterprise method equal to THB 1,304 million. It means that the NBTC has the ability to pay the compensation amount for spectrum refarming in the range of THB 1,288 million to 1,304 million.

It can be seen that the NBTC can successful refarm the 2600 MHz from the MCOT because the total revenue from the upper bound and lower bound from the full enterprise method are higher than the upper bound of benchmarking. Therefore, the NBTC and the MCOT are both satisfied with this outcome. The compensation for the refarming is agreed upon whereby the MCOT receives the compensation amount at the maximum value as shown by the benchmarking method and, at the same time, the NBTC pays for the compensation at an amount lower than the minimum value given as a result of the full enterprise method which is THB 775 million.

In addition, the total revenue that the NBTC and the MCOT can mutually agree upon regarding the compensation for the refarming is lower than the range of the total revenue that the NBTC has the ability and willingness to pay. Therefore, this causes a difference in the value when total revenue for the compensation and range of total revenue that the NBTC has ability and willingness to pay are compared together. Thus, it can be seen as a profitable move for the NBTC to bring 2600 MHz to auction in the market.

Consequently, the results of this research can be used as guidelines for future projects of the NBTC regarding the refarming of 2600 MHz. It helps for the more effective use of this spectrum within the telecommunications industry as well as helping the transition from 4G to 5G as long as the NBTC successfully pays compensation for the refarming of the spectrum.

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