Real options Valuation of Uncertain Investments Decision-making between 4G LTE and 4G WiMAX Mobile Network in Telecommunications Industry

Wichian Premchaiswadi, Santi Pattanavichai

1Graduate School of Information Technology in Business, Siam University, wichian@siam.edu
2Graduate School of Information Technology in Business, Siam University, pattanavichai@gmail.com

Abstract

In recent years, the world’s mobile market is transformed by E-3G UMTS and 4G mobile networks. Typically, infrastructure costs and revenue are two critical factors of any decision-making in regard to investment in 4G mobile network industry. The objectives of the study are categorized as follows: (1) to introduce real option theory and to discuss its applicability as a decision support tool, (2) to apply the real option approach into the selected two case studies so as to compare and show the advantage of option pricing model applied in 4G mobile networks in order to cope with investment uncertainty between LTE and WiMAX. Consequently, real option analysis is capable of providing managers a strategic tool to enhance the valuation of investment opportunities.

Keywords: Long Term Evolution (4G LTE), Worldwide Interoperability for Microwave Access (4G WiMAX), Mobile Network Operator (MNO), Mobile Virtual Network Operator (MVNO), Pricing Model, Real Options Analysis.

1. Introduction

In the past, mobile networks were operated primarily to provide voice services, short message, and low capacity data services. Nowadays, the trend is more focused on new mobile broadband networks that are capable of satisfying consumers’ demand for high-speed data. The E-3G UMTS mobile communications technologies include Evolved High-Speed Packet Access (HSPA+) and CDMA2000 3x (EV-DO Rev. B). The E-3G UMTS is a 3.75 G system which is able to support different values of capacity comparable to the ones needed for broadband mobile application. E-3G UMTS allows for introduction of the Always Best Connected (ABC) concept by Gustafson and Jonsson [1] and is an All-IP based network that supports additions and modifications to the E-3G UMTS network [2]. This is aptly illustrated in the case of fourth-generation technology (4G) which classically include mobile Worldwide Interoperability for Microwave Access (WiMAX) and Long Term Evolution (LTE), referred to as IMT-Advanced or 4th Generation (4G) systems, with even more ambitious technological challenges [3], [4].

One of the main objectives of (E-3G UMTS) networks and (4G) network architecture is to support a business model, which is Mobile Virtual Network Operator (MVNO) requirements in terms of flexibility, rapid deployment, and cost reduction over the infrastructure of 4G Mobile Network Operators (MNO). MVNO is characterized by neither having its own mobile license nor own mobile infrastructure. MVNOs buy spectrum and possibly also infrastructure from primary providers, referred to as Mobile Network operators (MNOs) [5], [6], [7], [8]. The objective of this study is mainly to focus the strengths of applying the Real Options Analysis for valuing strategic investments. The outcome of real options analysis is heavily dependent on the input parameters and the assumptions made, just as in traditional Discounted Cash Flow (DCF) analysis. Conventional DCF analysis should be complemented by real options analysis in order to determine the true NPV. Most capital investment projects have options (for example, option to expand or to abandon) that have value for decision making the investment project [9].

2. A high-level comparison between 4G LTE and 4G WiMAX mobile network
Key objectives of 4G LTE-Advanced networks are to support higher data rates, improve spectral efficiency, reduce network latency, support flexible channel bandwidths, and simplify or flatten the network by utilizing an all packet Ethernet/IP architecture. Limam et al. provided the third-generation virtualized architecture for the MVNO context [10]. Figure 1 illustrates 4G LTE network’s MNO and MVNO network in more detail. LTE’s MNO domain mainly provides four different sections which consist of User Equipment (UE), Radio Access Network (RAN), Core Network (CN), and Business Supports Section [11], [12], [13].

WiMAX provides the broadband wireless access for mobile devices. Several technologies used by WiMAX, such as Orthogonal Frequency-Division Multiple Access (OFDMA) and resource allocation methods with differentiated QoS are parts of Next Generation Networks (NGN) standards [14]. Figure 2 illustrates a 4G WiMAX network structure based on MNO and MVNO’s operational perspectives. WiMAX’s MNO mainly provides four different domains which consist of User Equipment (UE), Network Access Providers (NAPs), Network Service Providers (NSPs), and Business Supports Section.

3. The proposed pricing models for MNO and MVNO in 4G LTE and 4G WiMAX mobile networks

We propose a pricing model for MNO and MVNOs supporting MNO’s investment in 4G LTE and WiMAX networks. We investigate and conceptualize the relationship among MNO, MVNO, and other related variables in the proposed pricing model. MNO provides the dedicated resources for MVNOs. MVNO will have to pay to MNO an entry fee, annual license and those provided sources which price is called an access charge (α) [15]. The investment cost (K) in some cases is of major importance. However, the influencing factors of investment are very complex, and investors are often affected by the roles and effects of expected factors [16].

The main input is demand forecasts for the total market and estimates for lost market shares because of competition. The profits for existing companies and new entrants are as follows Pattanavichai et al. [11], [12]. MNO has the number of 1 to n MVNOs and defines \( q \) MVNO = access charges (pay to MNO), \( II = \) profit, \( p = \) ARPU (average revenue per user), \( q = \) number of customers, and \( TC = \) Total Cost. The Free Cash Flow (FCF) and profit of MNO are defined as

\[
FCF_{MNO} = (pMNOq_{MNO} + \alpha \sum_{i=1}^{n} q_{MVNO}) - OC_{MNO} \tag{1}
\]

\[
II_{MNO} = (pMNOq_{MNO} + \alpha \sum_{i=1}^{n} q_{MVNO}) - TC_{MNO} \tag{2}
\]

The parameters consist of \( p = \) ARPU (average revenue per user), \( q = \) number of customers, and \( OC = \) Operating Cost. The Free Cash Flow (FCF) and profit of MVNO are defined as

\[
FCF_{MVNO} = p_{MVNO} q_{MVNO} - OC_{MVNO} \tag{3}
\]
4. Real options valuation methodology

Many current studies have tried to propose a systematic method to evaluate commercial value and upcoming trends for investment opportunities by using real options [17]. This section reviews an investment in present value terms precedent variables which is calculated as the present value of future net free cash flows ($S_0$), discounted at a risk-adjusted factor which is the weighted average cost of capital ($WACC$), and the present value future of investment cost ($K_r$). To value an asset, the net present value ($NPV$) is needed. Therefore, the $NPV$ is given as follows:

$$\text{(NPV)}_{\text{MNO}} = \frac{\sum_{t=1}^{T} \left( P_{\text{MNO}} q_{\text{MNO}} + \alpha \sum_{t=1}^{Q} q_{\text{MNO}} \right) - OC_{\text{MNO}}}{(1+WACC)^t} - \sum_{t=1}^{T} \frac{K_r}{(1+r_f)^t}$$

$$\text{(NPV)}_{\text{MNO}} = \frac{\sum_{t=1}^{T} \left( P_{\text{MNO}} q_{\text{MNO}} - OC_{\text{MNO}} \right)}{(1+WACC)^t} - \sum_{t=1}^{T} \frac{K_r}{(1+r_f)^t}$$

Where ($FCF_t$) is the expected future net free cash flows at the end of the ($t$)th period and ($WACC$) is the discount rate per period (generally, it is assumed that the discount rate remains constant during the life of the project) [18]. A real option is a methodological approach with which an investment can be analyzed while factoring for flexibility and uncertainty. John Mun provides the following a novel view of evaluating capital investment strategies by taking into consideration the strategic decision-making process by Black-Scholes model [19], [20].

Telecommunications industry uses real options analysis as a decision tool for making key strategic decisions and prioritizing investments. James Alleman has shown the Real Options Theory for evaluating the telecommunication industry in terms of strategic, estimation and cost modeling [22]. Harmantzis and Tanguturi apply real options to estimate investments under uncertainty in two cases: (a) deferral of the expansion from 2.5G to 3G networks; and (b) expansion of a 2.5G network using Wi-Fi as an alternative technology [23], [24].

5. Real options: two case studies of MNO’s decision making for expansion the investment (4G LTE and 4G WiMAX mobile networks)

This section focuses on the real options valuation approach as a decision-making tool used in two cases of hypothetical investment decision. The assumptions made in both cases are sound and realistic. The mobile network operator in 4G network covers a geographic area of 513,115 square kilometer (Thailand’s information of total area comes from Home Page— http://en.wikipedia.org/wiki/Thailand); it is assumed that 10% are urban in the big city (The capital and largest city is Bangkok) and that the rest are suburban. A typical eNodeB in LTE cell site covers approximately 30 km², whereas a base transceiver station in WiMAX cell site covers an area of 50 km². Based on the above assumptions, a total of eNodeB in LTE 1,711 cell sites and a total of base transceiver station in WiMAX 1,027 cell sites covering the entire geographic area were estimated. The eNodeBs in LTE cell site and base transceiver station (BTS) in WiMAX are macrocells which include Relay Nodes (microcells) are mounted below roof level, cover high-traffic areas, and have a 1 km².

5.1 Case A: Option to expand of MNO’s investment decision in 4G LTE mobile network

The Mobile Network operator (MNO) has already acquired the required spectrum license to deploy 4G LTE network and has the exclusive rights to provide services. The capital expenditure (CapEx) of MNO is the necessary amount of money to acquire the physical assets to upgrade the infrastructure and plus the license cost in the first year only. The Operational Expenditure (OpEx) of MNO is the expenses that are incurred to operate and manage business. Revenues can be estimated from Average
Revenue Per User (ARPU), total number of customers, Access charges from MVNO (αq MVNO), and the number of MVNO.

5.1.1. Defining variables and parameters of MNO’s investment decision in 4G LTE mobile network

Certain assumptions have been made in order to perform the analysis. The strike price (\(K\)) is the present value of the investment cost, consisting of capital expenditures plus the license cost (\(L\)). The Operating Costs (\(OC\)) consisted of capital expenditure and operational expenditure. The capital expenditure comprises eNodeBs construction and Relay Nodes (microcells) costs which are assumed to be $150,000 per site and $1,000 per micro cell site, respectively (reported by Nortel and Alcatel Lucent Prices). Based on the above assumptions, a total of 1,711 eNodeB (cell sites) start up in the first year covering the entire geographic area were estimated and will be increased 20% per year. An integration cost is approximate to $50,000 per site. Evolved Packet Core (EPC) centers handover for 30-100 eNodeBs. In this study, we assume a maximum number of eNodeBs 100. EPC provides a simplified all IP architecture when combined with LTE and delivers a low cost and low latency infrastructure. EPC construction cost is approximate to $5 million. We assume that the construction cost of MNO’s head office and the license cost (\(L\)) are approximate to $50 million and $250 million, respectively.

Operational expenditures comprise the costs of eNodeBs, and EPC power supply to the site and maintenance cost. They are around $120,000 per year/site. The costs for sales, marketing and communications are 2.5% of total revenue. Equipment Operating Costs is 2.5% of total revenue. The Customer Care and Billing Costs (\(CCBC\)) consist of Customer acquisition costs (\(CAC\)), Customer retention costs (\(CRC\)), and Interconnect costs (\(IC\)). Each item is approximate to $12 per year. The current price of the underlying (\(S_0\)) is the present value of future free cash flows. The maturity of the option (\(T\)) is five years (FCC auction rules typically require companies to have their network partially developed and deployed after five years). For the DCF valuation, cash flows were the risk free rate (\(rf\)) of 4% and discounted using the average a (\(\text{WACC}\)) of 9% is consistent with the Telecom Industry Research & Analysis from Http://www.wikiwealth.com/ Company: telecom [25].

5.1.2. Cash flow breakdown and option valuation of MNO’s investment in the 4G LTE mobile network

Table 1 shows free cash flow projections of MNO’s investment decision in the 4G LTE network using equation (5). It is assumed that the base number of MNO and MVNO’s customers starts at 1,000,000 and 500,000, respectively, in Year 1 and grows at 20% per year. The number of MVNO is set to 3 and increased by 1 per year. The revenue is set to $250 per user in the first year, which is calculated based on ARPU. The ARPU will be decreased by 5% each year. Access charge is assumed to be 50% of ARPU by charging a price of $125 per MVNO’s customer in the first year, and will be decreased by 5% each year (a realistic, conservative assumption).

Table 1. Option to expand: free cash flow projections of MNO’s investment decision in the 4G LTE mobile network.
Table 2 shows the Total Costs ($TC$) breakdown for capital expenditure ($CapEx$) and operational expenditure ($OpEx$) from equation (3), including the present value of investment cost ($K$).

**Table 2.** Option to expand: Total cost projections of MNO’s investment decision in the 4G LTE mobile network.

<table>
<thead>
<tr>
<th>Year</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>eNode B (Cell sites)</td>
<td>1,711</td>
<td>342</td>
<td>411</td>
<td>493</td>
<td>591</td>
<td>710</td>
</tr>
<tr>
<td>Total of eNode B</td>
<td>1,711</td>
<td>2,053</td>
<td>2,464</td>
<td>2,957</td>
<td>3,548</td>
<td>4,258</td>
</tr>
<tr>
<td>Evolved Packet Core (EPC) centers</td>
<td>17</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Total of EPC</td>
<td>17</td>
<td>21</td>
<td>25</td>
<td>30</td>
<td>36</td>
<td>43</td>
</tr>
<tr>
<td>CapEx (in millions)</td>
<td>$727.75</td>
<td>$85.55</td>
<td>$102.66</td>
<td>$123.19</td>
<td>$147.83</td>
<td>$177.40</td>
</tr>
<tr>
<td>OpEx (in millions)</td>
<td>$0</td>
<td>$200.30</td>
<td>$249.81</td>
<td>$300.18</td>
<td>$358.22</td>
<td>$425.55</td>
</tr>
<tr>
<td>Operating Cost (in millions)</td>
<td>$727.75</td>
<td>$285.85</td>
<td>$352.47</td>
<td>$423.37</td>
<td>$506.05</td>
<td>$602.94</td>
</tr>
</tbody>
</table>

Discounting future cash flows with a $WACC$ of 9%, the present value of future free cash flows ($S_0$) is calculated to be $845.21$ million and the present value of investment cost ($K$) is calculated to be $727.75$ million from equation (5), the static NPV (no option) of the project is Static NPV (No option) = $S_0 - K = ($845.21 - $727.75) million = $117.46$ million. Clearly, the project has a positive NPV and therefore should be expanded the project. Within five years the company must make a decision whether to invest. The goal is to determine the value of the option to expand the investment (provided by the license). Knowing the option’s parameter the present value of future free cash flows $845.21$ million, the present value of investment cost is $727.75$ million (strike price). From equations (23), (24), and (25) we can calculate the parameters of the binomial tree as $u = 1.1780$, $d = 0.8489$ and $p = 0.5832$.

The evolution of the tree for the underlying asset, i.e., the firm value, is shown as Figure 3(a), considering that each time step of the tree equals 1 year. For the option to expand we use two more parameters. The future free cash flows ($S_0$) in the MNO assumption which equals $845.21$ million, and the expansion factor ($E$) which is assumed to be double, e.g. 200% growth in the company value post-expansion are used for this particular case.

From the trees above, the value of acquiring and expanding the firm’s operations is double this existing capacity less any acquisition costs. Static NPV (with option to expand) = (2) * $1,917.13 - $727.75 = $3,106.51$ million. Clearly the operator will choose at node P to exercise the option to expand the MNO investment. Therefore, the value of the option at this node is $3,106.51$ million. We similarly follow the same calculation for node P to make decision for expansion the investment. For example, at node U the operator cannot exercise the option to expand because the value of continuing with current network operation is $372.63$ million which is value of calculation which is (2) * $372.63$ million - $727.75$ million = $17.51$ million. Otherwise, if circumstances force the value of the firm’s operations down to such a low level as specified by node U, then it still can optimal to expand with the existing business because the project will be a profit at that point. See Figure 3(b) at node R which is $1,263.53$ million and which is (2) * $995.64$ million - $727.75$ million = $1,263.53$ million, the project has a decision making to expand the project.

**Figure 3.** Binomial Trees for underlying asset (a) and option to expand (b) in 4G LTE mobile network.
5.2 Case B: Option to expand of MNO’s investment decision in 4G WIMAX mobile network

The Mobile Network operator has already acquired the required spectrum license to deploy 4G WiMAX network and the growth rate of WiMAX is approximate to 10%.

5.2.1. Defining variables and parameters of MNO’s investment decision in 4G WiMAX mobile network

Certain assumptions have been made in order to perform the analysis. The investment cost ($K$), consisting of capital expenditure and operational expenditure. The capital expenditure comprises Base Transceiver Station (BTS) construction cost and Base Station (BS microcells) construction costs which are assumed to be $220,000 per site and $1,000 per micro cell site, respectively (The price of Base Transceiver Station (BTS) reported by White Paper to Beamform), Based on the above assumptions, a total of 1,027 BTS (cell sites) start up in the first year covering the entire geographic area were estimated and invest BTS 20% per year, and integration cost which is assumed to be $50,000 per site. Access Service Network Gateway (ASN-GW) handovers for 30-100 BTSs, in this study we assume 100 BTSs because BTSs (Macrocells) are mounted on top of a building or radio tower and cover a geographic area of 50 square kilometers. ASN-GW construction cost is assumed to be $500,000. Connectivity Service Network (CSN) center handovers for 100 BTSs, which consists of the set of Network Management System (NMS), Home Agent (HA), AAA server and AAA proxy server and it, is assumed to be $5 million. We assume that the construction cost of MNO’s head office and the license cost ($L$) are approximate to $50 million and $250 million, respectively. Operational expenditures are the expenses incurred in operating the network and keeping it functional. They comprise the costs of BTS, ASN-GW, and CSN center power supply to the site and maintenance cost. They are around $150,000 per year/site. The costs for sales, marketing and communications are 2.5% of total revenue. Equipment Operating Costs is 2.5% of total revenue. The Customer Care and Billing Costs ($CCBC$) consist of Customer acquisition costs ($CAC$), Customer retention costs ($CRC$), and Interconnect costs ($IC$). Each item is approximate to $12 per year.

5.2.2. Cash flow breakdown and option valuation of MNO’s investment in the 4G WiMAX mobile network

Table 3. Option to expand: free cash flow projections of MNO’s investment decision in the 4G WiMAX mobile network.

<table>
<thead>
<tr>
<th>Year</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNO’s Customers</td>
<td>0</td>
<td>1,000,000</td>
<td>1,100,000</td>
<td>1,210,000</td>
<td>1,331,000</td>
<td>1,464,100</td>
</tr>
<tr>
<td>MVNO’s Customers</td>
<td>0</td>
<td>1,000,000</td>
<td>1,650,000</td>
<td>2,200,000</td>
<td>2,750,000</td>
<td>3,300,000</td>
</tr>
<tr>
<td>The number of MVNO</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>MNO’s ARPU</td>
<td>$0</td>
<td>$250.00</td>
<td>$237.50</td>
<td>$225.63</td>
<td>$214.34</td>
<td>$203.63</td>
</tr>
<tr>
<td>Access Charges to MNO Revenue (in millions)</td>
<td>$0</td>
<td>$125.00</td>
<td>$118.75</td>
<td>$112.81</td>
<td>$107.17</td>
<td>$101.81</td>
</tr>
<tr>
<td>Free Cash Flow (in millions)</td>
<td>$0</td>
<td>$375.00</td>
<td>$457.19</td>
<td>$521.19</td>
<td>$580.01</td>
<td>$634.11</td>
</tr>
<tr>
<td></td>
<td>$0</td>
<td>$166.44</td>
<td>$201.81</td>
<td>$220.97</td>
<td>$225.05</td>
<td>$216.05</td>
</tr>
</tbody>
</table>

Table 3 shows the revenue projection for customers to the 4G WiMAX network and calculates free cash flows ($FCF$) from equation (5). It is assumed that the base number of MNO’s customers starts at 1,000,000 in Year 1, as noted, and grows at 10% per year. The part of MVNO, it is assumed that the base number of MVNO’ customers starts at 500,000 in Year 1, as noted, and grows at 10% per year.
The numbers of MVNO start in first year equal to 2 MVNOs and are estimated to increase 1 MVNO per year. The revenue table is calculated by charging a price of $250 per user in the first year. Furthermore, it is assumed that this charge, i.e., the ARPU, will decrease by 5% each year for the next five years. And α access charges (pay to MNO) is assumed to be 50% of ARPU by charging a price of $125 per user of the number of MVNO’s customers in the first year, will decrease by 5% each year for the next five years.

Table 4 shows the Total Costs (TC) breakdown for capital expenditure (CapEx) and operational expenditure (OpEx) from equation (3), as well as the figures used to calculate the present value of the investment cost (K).

<table>
<thead>
<tr>
<th>Year</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTS (Cell sites)</td>
<td>1,027</td>
<td>205</td>
<td>246</td>
<td>296</td>
<td>355</td>
<td>426</td>
</tr>
<tr>
<td>Total of BTS</td>
<td>1,027</td>
<td>1,232</td>
<td>1,479</td>
<td>1,775</td>
<td>2,130</td>
<td>2,556</td>
</tr>
<tr>
<td>ASN-GW</td>
<td>10</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total of ASN-GW</td>
<td>10</td>
<td>12</td>
<td>15</td>
<td>18</td>
<td>22</td>
<td>26</td>
</tr>
<tr>
<td>CSN Centre</td>
<td>10</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total of CSN Centre</td>
<td>10</td>
<td>12</td>
<td>15</td>
<td>18</td>
<td>22</td>
<td>26</td>
</tr>
<tr>
<td>CapEx (in millions)</td>
<td>$633.78</td>
<td>$66.76</td>
<td>$83.05</td>
<td>$96.13</td>
<td>$115.55</td>
<td>$138.42</td>
</tr>
<tr>
<td>OpEx (in millions)</td>
<td>$0</td>
<td>$141.80</td>
<td>$172.32</td>
<td>$204.10</td>
<td>$239.61</td>
<td>$279.64</td>
</tr>
<tr>
<td>Operating Cost (in millions)</td>
<td>$633.78</td>
<td>$208.56</td>
<td>$255.37</td>
<td>$300.22</td>
<td>$354.96</td>
<td>$418.07</td>
</tr>
</tbody>
</table>

Discounting future cash flows with a WACC of 9%, the present value of future free cash flows $S_0$ is calculated to be $793.04$ million and the present value of investment cost $K$ is calculated to be $633.78$ million from equation (5), the static NPV (no option) of the project is Static NPV (No option) = $S_0 - K = ($793.04 - $633.78) million = $159.26$ million. Clearly, the project has a positive NPV and therefore should be expanded the project.

Figure 4. Binomial Trees for underlying asset (a) and option to expand (b) in 4G WIMAX mobile network.

From equations (23), (24), and (25) we can calculate the parameters of the binomial tree as $u = 1.1042$, $d = 0.9057$ and $p = 0.6808$. The evolution of the tree for the underlying asset, i.e., the firm value, is shown as Figure 4 (a) considering that each time step of the tree equals 1 year. For the option to expand we use two more parameters. The future free cash flows $S_0$ in the MNO assumption which equals $793.04$ million, and the expansion factor $E$ which is assumed to be 1.5, e.g. 150% growth in the company value post-expansion is used for this particular case. The growth rate of customers is 10%. Starting at the end of the tree at terminal node P, the value of the option can be obtained as follows: it is the maximum between exercising the option i.e., company decides to expand its network or not exercising and continues its current operations (no expansion). From the trees above, the value of acquiring and expanding the firm’s operations is double this existing capacity less any acquisition costs.
Static NPV (with option to expand) = $(1.5) \times \$1,301.63 - \$633.78 = \$1,318.67$ million. Clearly the operator will choose at node P to exercise the option to expand the MNO investment. Therefore, the value of the option at this node is $\$1,318.67$ million. See Figure 4 (b) at node Q which is $\$1,067.61$ million and which is $(1.5) \times \$1,067.61$ million - $\$633.78 = \$967.64$ million, the project has not a decision making to expand the project.

6. Conclusion

The paper reveals the true motives behind the real option approach to compare the investment opportunities between two designated cases (LTE and WiMAX) both applied in 4G networks. As a result, real option theory could provide an appropriate framework to study decision-making processes of investment in telecommunication industry of Thailand. In general, this paper focuses on several key factors as follows: (1) investment costs and operating costs - including capital expenditure (CapEx) and operational expenditure (OpEx), (2) number of customers for MNO and MVNO, and (3) uncertainty around the market conditions in future years.

In the first case, Mobile Network Operator (MNO) owns the spectrum license for 4G LTE network but considers deferring expansion for five years, until favorable market conditions are developed. For the results of assumption, it is found that an expansion of MNO’s investment in 4G LTE network is a profitable solution, as both the estimated ARPU and Access charge to MNO and uncertainty around the number of customers of MNO are high. The value of the option is low, given the prevailing market conditions and the high investment cost. Even in situations of high volatility that favor the value of the option, the recommendations made to MNO did not change (for realistic volatility levels). Uncertainty regarding the number of customers is a major issue in this case. The analysis suggests that when only revenue from the new 4G LTE network’s customers is considered, expansion is exercised in the fifth of the three nodes in upper factor.

In the second case, Mobile Network Operator (MNO) owns the spectrum license for 4G WiMAX network. Hereby, we selected the value of the option to expand in this study. In fact, MNO’s 4G WiMAX network has the investment cost which is less than the investment of MNO’s 4G LTE network. However, MNO’s 4G WiMAX network is considered for the expansion to be exercised only one node of upper factor in the fifth year. In this case study of MNO’s 4G LTE network has the rate of growth in the market conditions and regulatory policies in future years to be 20 % per year, which is more than MNO’s 4G WiMAX network to be 10%. However, for mobile network operators, the investment duplication’ strategy is generally not available, or in any case, is extremely costly. Yet the threats of a failed binary technology decision are obvious: low revenue, profitability and valuation. Furthermore, in this study, we considered that MNO should make decision to invest on 4G LTE networks due to an increase in cash flow breakdown which will result to expansion of MNO’s investment in the fifth year. As a final point, if a real options approach was not applied, the company would be undervalued because it has a strategic option to develop its current operations but not a commitment to do so and would probably not do so unless market conditions consider it optimal.

7. References


