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A Financial Feasibility Study on the New Aircraft Investment Based on Multiple Perspectives -- A Case Study of Boeing 7E7

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Abstract: Commercial aircraft design and manufacture is known for the characteristics of high investment, high risk and high technology. Typically it is the number one priority to analyze financial feasibility on the manufacturer level to measure future risks and avoid strategic decision-making mistakes. Unlike the fruitful results in the research on technical feasibility of the engine and aircraft body, few studies have been conducted on financial feasibility of new aircraft. This paper formulated a three-step investment feasibility analysis and evaluation method based on multiple perspectives on the manufacturer company level, considering the determination of financial factors, capital structure, sensitivity analysis, economic attractiveness and comparative analysis. Based on the analysis and evaluation theory, this paper took Boeing 7E7 project for instance, demonstrated how a three-step method can be utilized to measure financial feasibility of a new aircraft project. In the first step, the determination of five financial indicators including beta, risk-free rate, market risk premium, cost of equity, cost of debt was illustrated for the project evaluation. In the second step, sensitivity analysis was conducted with @Risk software and comparative study between the financial indicators was clarified. In the third step, economic attractiveness analysis was demonstrated, where macro and micro environment assessment was explained. With the Boeing 7E7 project demonstration, the three-step method was proved to be an effective and applicable method for new aircraft project evaluation. The method proposed in this paper could offer references for general aircraft manufacturers when launching new commercial aircraft like COMAC C919, C929 and other homemade large aircraft.

Keywords: Financial Feasibility, New Aircraft, Project Evaluation, Sensitivity Analysis

1. Introduction

Commercial aircraft design and manufacture is the crown of the aviation industry, with the characteristics of high investment, high risk and high technology [1]. The R & D and manufacturing of large commercial aircraft has become a national strategic research project in China, with the most complex technology, the highest technical requirements, and the largest international influence and industrial value involved.

The large commercial aircraft project involves critical national interests and is a strategic decision of the family. As this project is of great importance, it also has great potential risks, namely financial risk, safety risk, technical risk. The success of the large aircraft project depends on a number of factors. On the company level, typically it is the number one priority to analyze if it is feasible financially. For future risks, analyzing and summarizing historical experience is an important method to reduce uncertainty and avoid strategic decision-making mistakes. This paper analyzed the financial feasibility of Boeing 7E7 project in depth from the perspective of investment, risk assessment, market competition, and other internal and external environment. It aims at offering a set of financial assessment methods for the reference of R & D and manufacturing of COMAC C919, C929 and other homemade large aircraft.

The Boeing Company is a dominated US aircraft manufacturer. After its success in the early 1990s, Boeing had found itself in a financial slump due to failed projects. In 2003, Boeing announced a new aircraft, the 7E7, which was later named "Dreamliner". This aircraft would be lighter, use less fuel and have lower operating costs [2]. In 2004, Boeing launched the 787 program with an order from All Nippon Airways for 50 aircraft, and in 2005, Boeing received an order of 60 more from the People's Republic of China [3].

Boeing completed the initial airworthiness testing for the 787 in 2010, and in 2011, it received FAA certification. All seemed to be going well for Boeing, but on January 16, 2013, there were 50 787s that were in service were grounded due to battery issues, and Boeing suspended all deliveries [4]. However, by March, Boeing got approval from the FAA to test and certify improvements to the 787's batteries and was able to complete all testing by April. The first 787 was rolled out in January 2014. By then, Boeing had already broken the record for wide-body aircraft sales when it reached 1,000 orders and was able to manufacture them at a rate of 10 aircraft per month, which was the fastest rate ever for any twin-aisle aircraft to date.

Based on the premise that Boeing plans to invest in B7E7, under the guidance of macro and micro analysis, quantitative and qualitative analysis, as well as investment feasibility analysis theories, this paper makes a detailed evaluation and analysis of various indicators of B7E7 from the aspects of basic situation, industry overview and market analysis, competitive environment assessment, company financial analysis, investment income calculation and risk analysis, and carries out sensitivity analysis according to different assumptions. Using company examples and referring to relevant literature, this paper constructs the feasibility analysis process of investing in the research and development of aircraft, and establishes a set of investment feasibility analysis and evaluation model, hoping to provide reference significance for other aircraft manufacturers to invest in the feasibility analysis of new aircraft.

2. Review of Research

It can be concluded from the existing literature that scholars have achieved fruitful results in the research on technical feasibility of the engine and aircraft body, especially in some key technique solutions. However few studies have been conducted on financial feasibility of new aircraft.

At present, the international frontier research results believe that the project evaluation theory based on the rule of net present value is wrong, and the correct method is to take the real option theory as the core to determine the value of the project through the analysis of various rights and values of the project, concluded by Tian Li (2008) [5]. Based on the cost volume profit model, the break even analysis of China's large passenger aircraft is carried out by Zhang Cuifen (2009) [6]. Wang Tianjie and Zhao Wenhua (2010) [7] suggested, in order to reduce financial risks, we should fully consider the economic value of large aircraft products and formulate a detailed fund use plan. It is also necessary to strengthen cost management to make the project obtain greater economic benefits [8].

In general, the current research on financial feasibility of new aircraft is far from enough. The existing literature research perspective is relatively simple and only analyze from single perspective, rather than link financial evaluation and risk assessment together. On the one hand, it is difficult to estimate financial results without the guidance of scientific evaluation process and tools. On the other hand, investment risk must be considered under both external and internal environment. Therefore, in order to make the financial decision precisely and scientifically, it is necessary to formulate a set of financial feasibility evaluation process for designing and launching new aircraft project.

3. Project Evaluation

Since there was no direct information about the required rate of return (WACC), the cost of equity, the cost of debt for the business segment, beta, risk-free rate, and market risk premium, this report would figure out this information by various methods, including desk research, empirical research, comparable analysis and so on.

3.1. Determination of Beta

Boeing consists of two business segments, the defense market and the commercial aircraft market. Obviously, the two segments are totally different in operations, risk management, and profits. Therefore, the beta provided in the case for defense market could not be used for the assessment of the 7E7 project.

After the calculation of unleveraged beta for Boeing as a whole and the unlevered beta for its defense market, the unlevered beta for commercial aircraft market could be figured out and then re-levered to find the cost of equity and WACC.

$$\text{Unlevered } \beta = \frac{\text{Levered } \beta}{[1+(1-T_C)\times\frac{D}{E}]} \tag{1}$$

$$\beta \text{ of Boeing} = \%\text{ Revenue} \times \text{Defense } \beta + (1-\%\text{ Revenue}) \times \text{Commercial } \beta \tag{2}$$

$$\text{Levered } \beta = \text{Unlevered } \beta \times [1+(1-T_C)\times\frac{D}{E}] \tag{3}$$

There were various methods to determine which beta could better represent the value based on assumptions. Beta was influenced by the chosen market index, period, and the frequencies of observations. S&P 500 index would conclude 500 largest companies listed on NYSE or NASDAQ, which represented about 70% of the total value of the stock market in the U.S. Hence, this index could be used for beta calculation of Boeing commercial segment. In addition, this report preferred a longer period data set. Therefore, 60 months would be favorable.

After analysis, this case would use 1.182 as the levered beta for Boeing commercial based on the S&P 500 index observed in 60 months. Please see table 1 as below.

Table 1. *Beta Estimation.*

	Boeing commercial	Boeing commercial
Estimated betas		
1. Value Line	1.037	1.391
2. Calculated against		
60 months	0.881	1.182
21 months	1.201	1.611
60 trading days	1.806	2.423
3. Calculated against		
60 months	1.084	1.453
21 months	1.359	1.823
60 trading days	2.022	2.712

3.2. Determination of Risk-Free Rate

According to the desk research results, the yield on three-month U.S. Treasury bill rate was 0.85% in June 2003, and the 30-year Treasury bond rate was 4.56%. The project would need long period from designing to launching and delivering. Meanwhile, long period bond rate was more reliable than short period rate. Hence, 4.56% was selected as the risk-free rate for WACC calculation in this paper.

3.3. Determination of Market Risk Premium

Based on Ibbotson and Chen's article on Financial Analysis Journal in 2003 [9], the historical returns from 1926 to 2000 with the consideration of market risk premium was 5.9%. In addition, the historical data of market risk premium were ranged between 5% and 7% on average. On the baseline analysis, this paper would assume 7% as market risk premium in order to achieve a higher WACC.

3.4. Determination of Cost of Equity

The cost of Equity was determined by the Capital Asset Pricing Model (CAPM) model.

$$R_E = R_F + \beta \times R_{Market\ Risk\ Premium} \quad (4)$$

Based on the parameter analysis above, the beta was 1.182, risk-free rate was 4.56%, and market risk premium was 7.00%. According to the analysis, the cost of equity was assumed as 12.833% according to S&P 500 index in 60 months. Please see table 2 as below.

Table 2. *Estimation of Cost of Equity.*

	Cost of Equity
1. Value Line	14.300%
2. Calculated against the S&P 500 index	
60 months	12.833%
21 months	15.837%
60 trading days	21.520%
3. Calculated against the NYSE composite index	
60 months	14.733%
21 months	17.321%
60 trading days	23.545%

3.5. Determination of Cost of Debt

Debt is an important source of financing for new projects. For the calculation of Cost of Debt, this analysis assumed the weighted average of the yield to maturity of all Boeing's debt, which was 5.286%. Also, all debt were considered as bonds. Please see table 3 as below.

Table 3. *Estimation of Cost of Debt.*

Debt Amount	Coupon	Price	YTM	Weighted YTM
202	7.625%	106.175	3.911%	0.183%
298	6.625%	105.593	3.393%	0.234%
249	6.875%	110.614	3.475%	0.200%
175	8.100%	112.650	4.049%	0.164%
349	9.750%	129.424	5.470%	0.441%
597	6.125%	103.590	4.657%	0.642%
398	8.750%	127.000	6.239%	0.574%
300	7.950%	126.951	5.732%	0.397%
247	7.250%	114.506	6.047%	0.345%
249	8.750%	131.000	6.337%	0.365%
173	8.625%	138.974	5.805%	0.232%
393	6.125%	103.826	5.850%	0.531%
300	6.625%	106.715	6.153%	0.427%
100	7.500%	119.486	6.173%	0.143%
173	7.825%	132.520	5.777%	0.231%
125	6.875%	110.084	6.191%	0.179%
4328				5.286%

3.6. Capital Structure and Determination of WACC

According to the empirical analysis, the market-value debt/equity ratio was 0.525 to 1. This paper would use the range as a proper capital structure to do the baseline project evaluation.

$$\text{WACC} = \frac{V_E}{T_V} \times R_E + \frac{V_D}{T_V} \times R_D \times (1 - T_c) \quad (5)$$

Based on the WACC equation, market value of equity V_E was 1, market value of debt V_D was 0.525, and total market value of debt and equity T_V was 1.525. Return on equity was 12.833%, return on debt was 5.286%, and tax rate was 35.00%. Hence, WACC was 9.598% according to the S&P 500 index in 60 months. Please see table 4 as below.

Table 4. *Estimation of WACC.*

	Boeing commercial levered	Cost of Equity	WACC
1. Value Line	1.391	14.300%	10.560%
2. Calculated against the S&P 500 index			
60 months	1.182	12.833%	9.598%
21 months	1.611	15.837%	11.568%
60 trading days	2.423	21.520%	15.295%
3. Calculated against the NYSE composite index			
60 months	1.453	14.733%	10.844%
21 months	1.823	17.321%	12.541%
60 trading days	2.712	23.545%	16.622%

4. Sensitivity Analysis

In order to increase the reliability of the analysis, this paper would use @Risk software to do sensitivity analysis for the selected crucial parameters for project valuation, namely minimum price, price premium, cost of goods sold, working capital requirement and so on. In addition, all analysis was based on the assumption that there would be no delay in the delivery of the 7E7 project. The outputs for the analysis were WACC and IRR.

4.1. Range of Assumptions

Range of assumptions for all the input parameters were defined by triangle distribution (with lower limit, mean and upper limit). Please see the value range of different inputs as table 5 below.

Table 5. *Range of Assumptions.*

Assumptions	Low	Mean	High
Minimum Price 7E7	$114.50	$120.50	$125.00
Minimum Price 7E7 stretch	$144.50	$150.00	$155.00
Price Premium	3.00%	5.00%	7.00%
Cost of goods sold (% of sales)	75.00%	80.00%	85.00%
Working-capital requirement (% of sales)	4.00%	6.70%	9.00%
General, selling, and administrative (% of sales)	5.00%	7.50%	9.00%
R&D expense (% of sales)	1.00%	2.30%	4.00%
Capital expenditure (% of sales)	0.10%	0.16%	0.20%
Development costs (2004-2009)	$6,000.00	$8,000.00	$10,000.00
Marginal effective tax rate	30.00%	35.00%	40.00%
Total number of planes Yr 1-20	2,000	2,500	3,000
Risk Free Rate (Rf)	3.000%	4.560%	6.000%
Risk Premium	5.000%	7.000%	9.000%
ß Commercial	1.182	1.611	2.423
Market-value debt/equity ratios	0.400	0.525	0.650

4.2. Key Drivers and Results

1) WACC

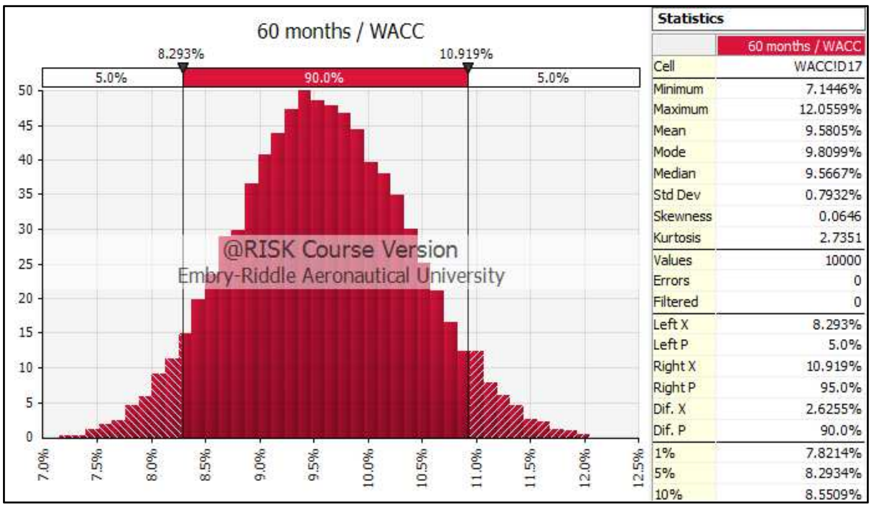


Figure 1. *WACC for 7E7 Project.*

Based on the sensitivity analysis, the range of WACC was from 7.1446% to 12.0559%. There was 90% probability that WACC would fall within the range of 8.293% to 10.919%. The standard division was 0.7932%, and distribution shape was a normal distribution. Please see figure 1 as above.

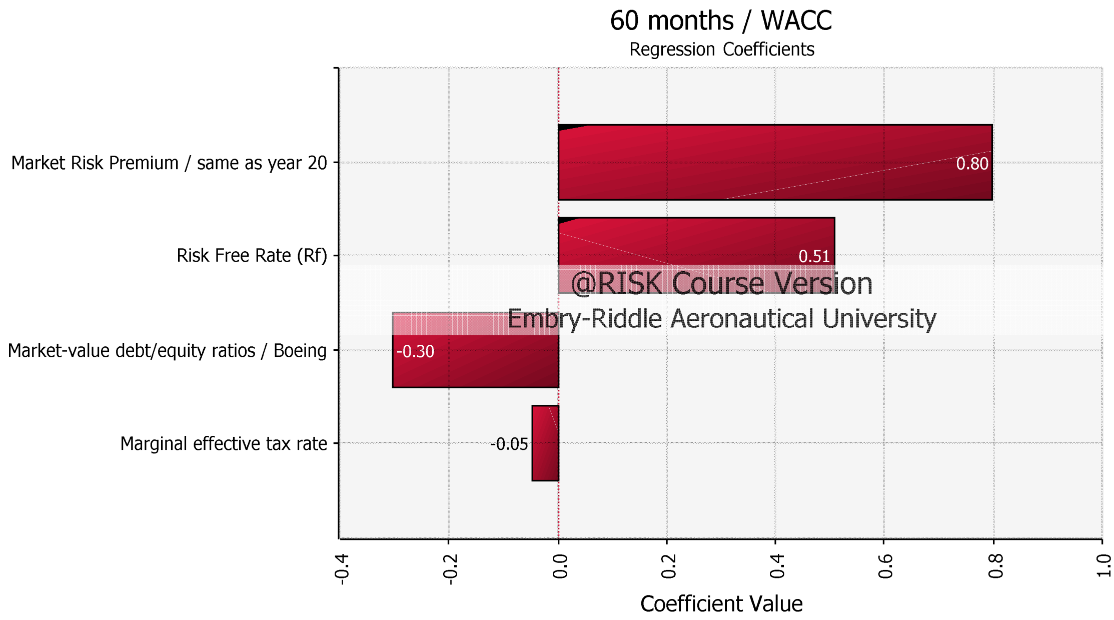


Figure 2. *Regression Coefficients of WACC.*

For regression coefficients analysis, there were four drivers influenced the value of WACC, namely market risk premium, risk-free rate, market value debt/equity ratios, and marginal effective tax rate. The first two had positive effect on the results, and the last two had negative impact. The key driver was market risk premium, which was 0.80 on influential factor. Risk-free rate had a moderate effect here, which was 0.51. The larger these values were, the higher WACC was. Please see figure 2 as above.

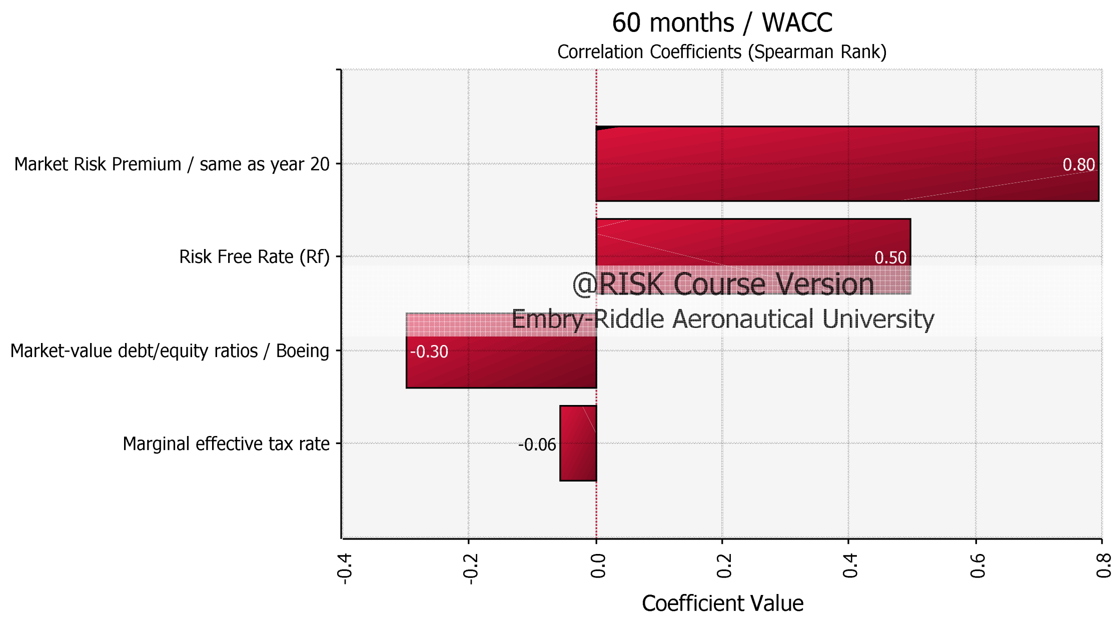
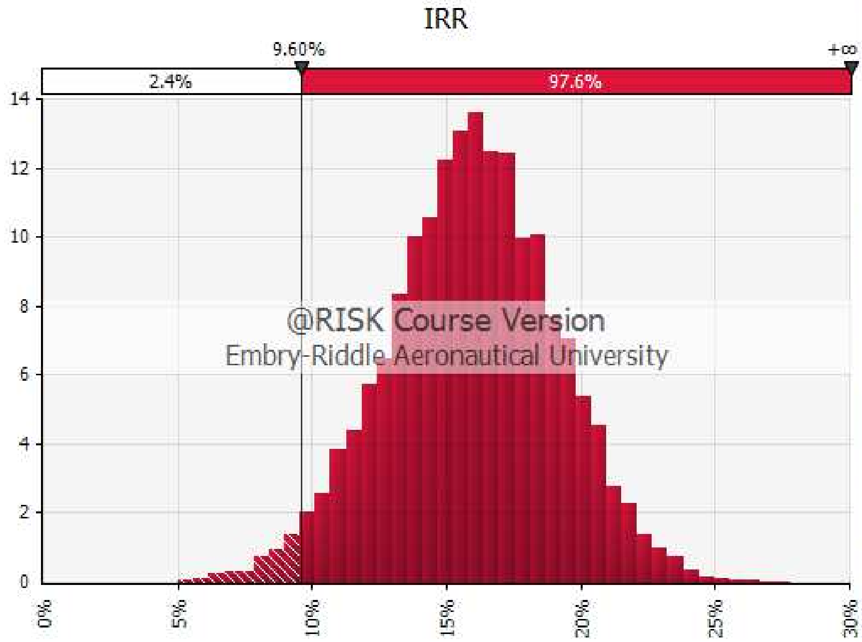


Figure 3. *Correlation Coefficients of WACC.*

For correlation coefficients analysis, there were four drivers influenced the value of WACC, namely market risk premium, risk-free rate, market value debt/equity ratios, and marginal effective tax rate. The first two had positive effect, and the last two had negative impact. The key driver was market risk premium, which was 0.80 on influential factor. Risk-free rate had a moderate impact here, which was 0.50. The larger these values were, the higher WACC was. Please see figure 3 as above.

2) IRR



Statistics	IRR
Cell	FCF!B29
Minimum	4.992%
Maximum	27.817%
Mean	15.980%
Mode	16.065%
Median	16.036%
Std Dev	3.126%
Skewness	-0.0891
Kurtosis	3.0117
Values	10000
Errors	0
Filtered	0
Left X	9.60%
Left P	2.4%
Right X	+∞
Right P	100.0%
Dif. X	+∞
Dif. P	97.6%
1%	8.435%
5%	10.720%
10%	11.910%

Figure 4. *IRR.*

Based on the sensitivity analysis result, the range of IRR was from 4.992% to 27.817%. There was 97.6% probability that IRR was larger than 9.60%. The WACC calculated from baseline analysis was 9.598%. It meant that there was around 97% probability that IRR would be larger than expected WACC. The standard division was 3.126%, and distribution was a normal distribution. Please see figure 4 as above.

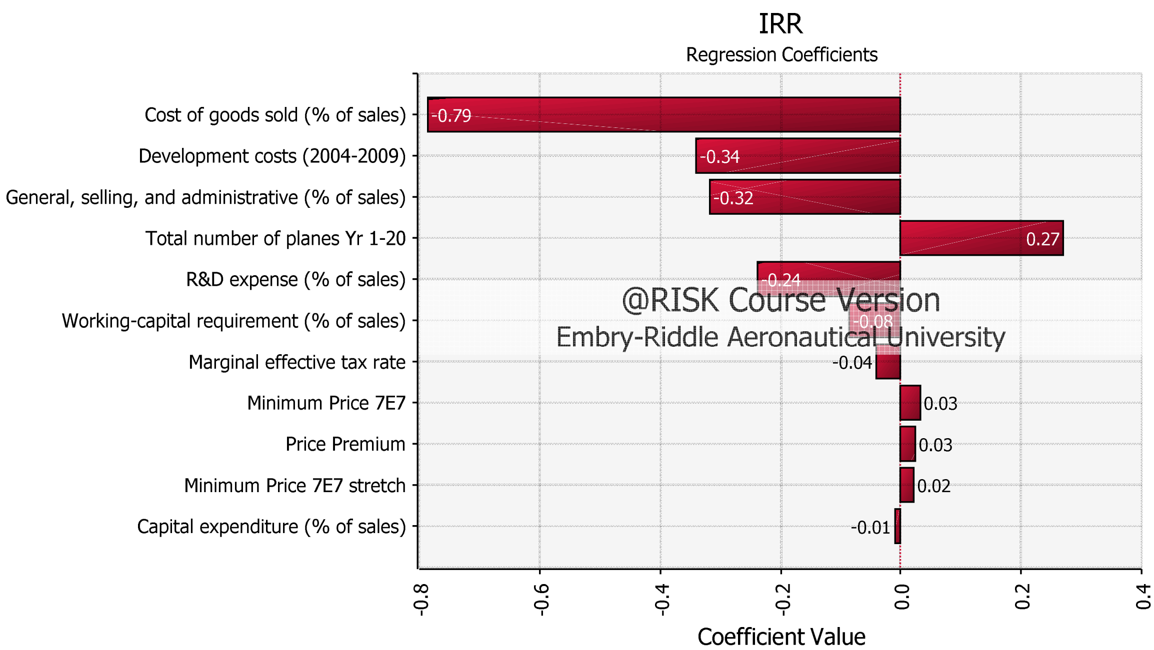


Figure 5. *Regression Coefficients of IRR.*

For regression coefficients analysis, there were 11 factors that had impacts on IRR. The key driver was the cost of goods sold, which was -0.79 on influential factor. Development costs, General selling and administrative, and R&D expenses had moderate negative influence, which were -0.34, -0.32, and -0.24 respectively. A total number of planes had moderate positive influence, which was 0.27. Working capital requirement, marginal effective tax rate, minimum price 7E7, price premium, minimum prices 7E7 stretch, and capital expenditure had minor influences on the value. Please see figure 5 as above.

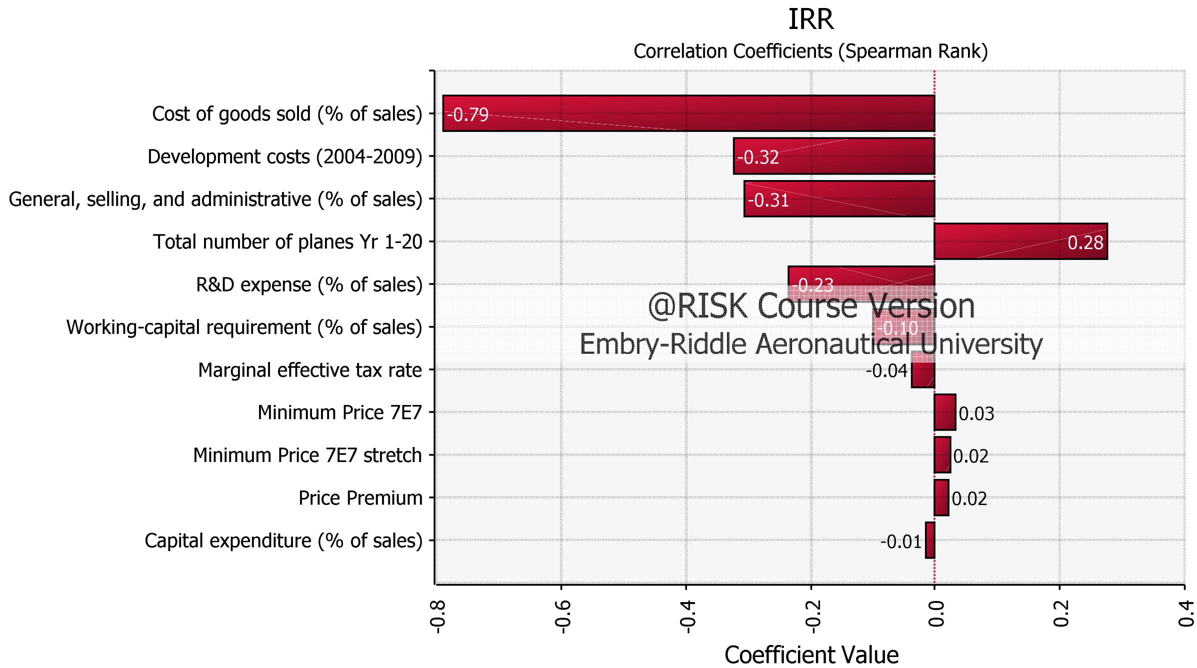


Figure 6. *Correlation Coefficients of IRR.*

For correlation coefficients analysis, there were 11 factors that had impacts on IRR. The key driver was the cost of goods sold, which was -0.79. Development costs, General selling and administrative, and R&D expenses had moderately negative influences, which were -0.32, -0.31, and -0.23 respectively. A total number of planes had moderate positive influence, which was 0.28. Working capital requirement, marginal effective tax rate, minimum price 7E7, price premium, minimum prices 7E7 stretch, and capital expenditure had minor influences on the value. Please see figure 6 as above.

4.3. Comparison

Based on public information and desk research, a sensitivity analysis was also conducted to find the potential IRR under various scenarios. Please see table 6 as below.

Table 6. *Sensitivity analysis.*

Unit Volume	Price Premium Above Expected Minimum Price			
	0%	5%	10%	15%
1,500	10.50%	10.90%	11.30%	11.70%
1,750	11.90%	12.30%	12.70%	13.10%
2,000	13.00%	13.50%	13.90%	14.40%
2,250	14.10%	14.60%	15.10%	15.50%
2,500	15.20%	15.70%	16.10%	16.60%
2,750	16.10%	16.60%	17.10%	17.60%
3,000	17.10%	17.60%	18.10%	18.60%

Development Costs	Cost of Goods Sold as Percentage of Sales			
	78%	80%	82%	84%
$6,000,000,000	21.30%	18.70%	15.90%	12.60%
$7,000,000,000	19.40%	17.00%	14.40%	11.30%
$8,000,000,000	17.90%	15.70%	13.20%	10.30%
$9,000,000,000	16.60%	14.50%	12.10%	9.40%
$10,000,000,000	15.50%	13.50%	11.20%	8.60%

Overall, the more aircraft to be sold, the higher IRR would be possible to achieve. The fewer development costs to be spend, the higher IRR could be achieved.

Both the sensitivity analysis and calculation valuation found the same results. Development costs had a moderately negative impact, and a total number of planes had a moderately positive impact on IRR. The cost of goods sold had a strongly negative impact, and price premium had a minor positive impact on IRR.

However, there were many other factors might have influenced on the IRR, which was not taken into consideration or not shown in this sensitivity analysis. The analysis included the majority of the factors, and for other detailed economic influences and market environments analysis, please see the next sections of Porter's five forces analysis and SWOT analysis.

5. Economic Attractiveness Analysis

Commercial aircraft industry has a strong competition among manufacturers [10]. Therefore, looking more closely the industry and organization might be helpful to evaluate the 7E7 project. For analyzing the industry, Michael Porter's five competitive forces had been considered, and SWOT analysis had been followed for evaluating the Boeing company and the project as a whole.

5.1. Porter's Five Forces Analysis of the Industry

A framework provided by Michael Porter includes five competitive forces that need to be considered for industry analysis. The theory framework was shown as below figure 7.

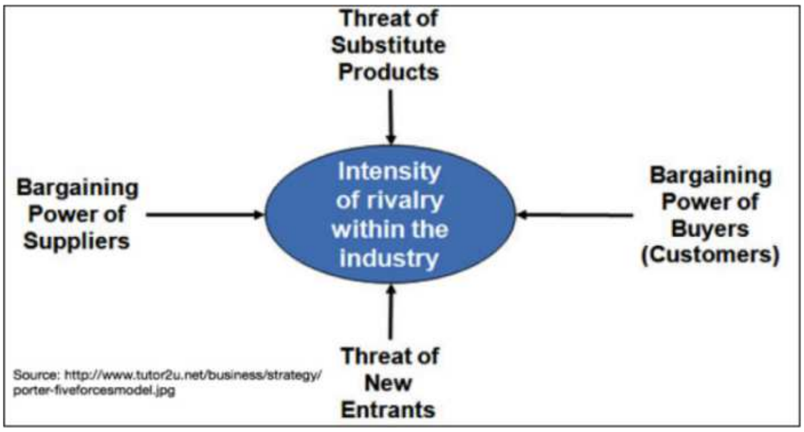


Figure 7. *Competitive Forces in An Industry.*

1) Bargaining Power of Buyers: Fairly Low

For reviewing this aspect, the characteristics of the industry such as limited principal manufacture and high capital investment by buyers must be considered. Even though buyers may have high bargaining power according to the purchasing in bulk, long-term contract with the seller for mitigating high capital investment lowers the bargaining power. Technical factors and maintenance costs make the switching cost high, and it lowers the bargaining power of buyers as well.

2) Bargaining Power of Suppliers: Fairly High

According to the Cohan, P. (2011) [11] the bargaining power of suppliers is considered high regarding the market power of Boeing. Boeing outsources many parts to a large number of suppliers throughout the globe network. Even though there are a large number of suppliers, Boeing experienced some delays for the delivery of orders. These are mainly due to a supply chain management problem. This situation makes Boeing highly dependent on the suppliers, so bargaining power of suppliers is regarded fairly high.

3) Threat of New Entrants: Fairly Low

The threat of new entrants of the market is relatively low because of high monopoly power of the aircraft manufacturing industry and high fixed cost. Initial investment and several restrict such as massive level of technological expertise and high R&D budget are contributes of high entry barriers as well. It does not mean that there is no possible new competitor such as growing China COMAC but still the threat of new entrants seems low.

4) Threat of Substitutes: Moderate

Rapid development of high-speed rails might affect the aircraft industry gradually in the future, but still, these cannot substitute the aircraft especially long-range and overseas market. More and more new aircrafts are needed as the growing of population and wealth. The requirement of consumers for faster, safer, more comfortable and environment-friendly is consistently growing.

5) Competitive Rivalry: Fairly High

According to Wilhelm (2014) [12], competitive rivalry is considered high in aircraft manufacturing market. There are mainly two dominant competitors in this market globally as more and more acquisition happened, both Boeing and Airbus have strong R&D power and robust supply chain [13]. Boeing aims to acquire more related companies like Embraer to keep competitive comparing to Airbus.

5.2. SWOT Analysis of Boeing 7E7 Project

SWOT analysis is a common macro analysis method for initial and external environment analysis. SWOT stands for Strengths, Weaknesses, Opportunities, and Threats. According to Schmitt (2015) [14], SWOT analysis enables to analyze factors affecting a company's future strategy.

1) Strengths

Strengths are usually accumulating as a company growing over time, it demonstrates the advantages over other competitors in the industry. The excellent performance in operating, cost efficiency, auto system, cabin design and enthronement makes Boeing 7E7 outstanding in commercial aircraft especially in the wide body series. Schmitt (2015) [14] indicates several strengths of Boeing. To begin with, as the second largest defense contractor of the US government, Boeing dominates a strong market share in commercial aircraft and defense system. In addition, it has a wide array of commercial jetliner families, and these aircraft make it possible to meet customer needs in the various market. Furthermore, the company endeavors to develop technically advanced aircrafts to gain an advantage over its competitors.

2) Weaknesses

The company's outsourced supply chain sometimes harms Boeing's reputation for the inefficiency of the factories out of WA state and the technical inconsistency in some parts, resulting in delayed schedule and defective or unmatched assemblies. Schmitt (2015) [14] point out that production delays, cost overruns, and technical problems in Boeing's 787 Dreamliner project had drained a lot of cash beyond the company's projected estimates.

3) Opportunities

Prospects for growth and the potential for its revenues represents company's opportunity. The consistent support of the US government and rapid growing air traffic demand in all the regions especially in Asia-Pacific are the two primary driving forces for Boeing. Besides, more and more strict international policies and rules on emission and noise keep the chasers far behind.

4) Threats

External factors beyond the company's direct control, which can negatively impact its prospects considered threats. More and more dramatic competition from Airbus especially after it purchased Bombardier C series is regarded the most straightforward counter force. Other global competitors such as Embraer share the market in different segments [15]. Growing entrants are staring at the lucrative commercial map. More and more attention is paid to the independent research and development of aircraft from governments with the tension of international relations. This may also affect the supply chain of Boeing negatively as industrial transfer happens.

6. Conclusion

Through the analysis, under general circumstances with no delivery delay, the 7E7 project proved to be a favorable and attractive investment for Boeing and its shareholders. It was true that there existed various risks, such as outsourcing problems, technology problems, and so on. There was no doubt that 7E7 could be another revenue booster for Boeing in the severe competition with Airbus. Even though Airbus might develop a similar product to balance 7E7 aircraft, the position of this aircraft would remain strong in the market.

Based on the calculated WACC of 9.598%, there was 97% of possibilities that IRR would be greater than WACC, which means the project worth investing. Furthermore, there was also at least 50% chance of IRR would be larger than 15.668% in the baseline analysis. Unless the 7E7 would be delay forever or failed, which might not happen in reality. All kinds of investments could be considered as "gambling" behaviors, but this report recommended that the 7E7 project had a higher chance to achieve the final goals to make profits and gain more market share in the battle with Airbus.

The three-step evaluation process proposed in this paper, that is 'project financial evaluation- sensitivity analysis-economic attractiveness analysis', proved to be an effective and applicable method for new aircraft project evaluation. In the first step, the manufacturer would gain estimated weighted average cost of capital in the long run. In the second step, the sensitivity analysis gives the manufacturer a precise view on which indicators influence the financial results on what extent and positively or negatively, with which the manufacturer could treat different risks at diverse priority. In the third step, qualitative analysis for macro environment, namely market risks, competition forces, external threats are assessed, which are difficult to measure quantitatively in the first two steps.

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