MGT 456

Final Take Home case

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I. Executive Summary

Boeing, as a global leader in the aerospace equipment industry, is dedicating to mitigate supply chain risks, especially the risks related to raw materials production.

It first introduced Boeing Raw Material Strategy (BRMS) to aggregate and buy raw materials on behalf of its supplier in 1998. BRMS can be divided into five phases: Forecasting, Ordering, Mill Production, TMX processing and shipment, and scrap recovery.

The key components of risks for Boeing are Mill Production Risk, Inaccurate Forecasting Risk, Late Deliveries Risk, and Scrap Recovery Risk.

II.a Supply Chain Risk

As for Boeing, the Supply chain risk stands for the risks related to raw materials production, including aluminium and Titanium. As Boeing relied on supplier to deliver quality parts on time to assemble airplanes, if raw materials are in shortage, Boeing's supplier will not be able to produce parts and thus, Boeing will not be able to deliver the airplane to its customer.

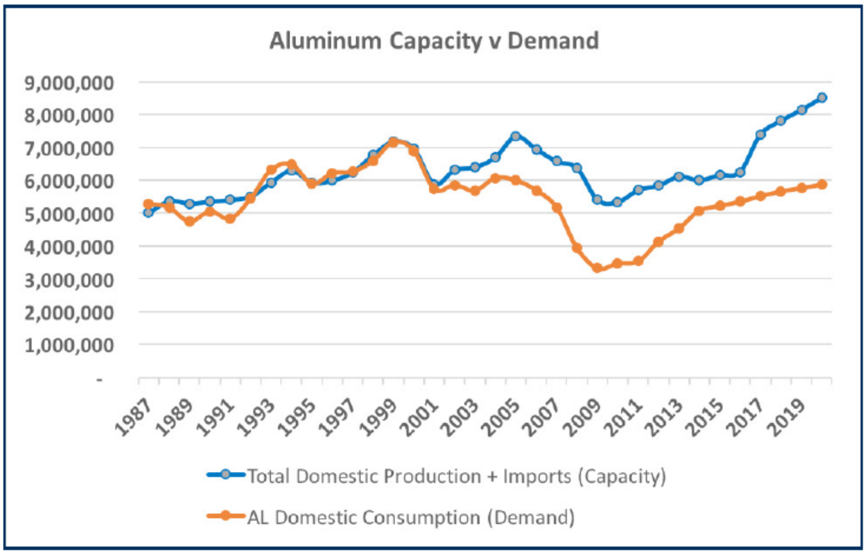
II.b BRMS Strategy

The key risk management strategy of Boeing is Boeing Raw Material Strategy (BRMS), first introduced in 1998. The main component of BRMS for Boeing is aggregating and buying raw materials on behalf of its supplier. BRMS assisted Boeing in leveraging economies of scale and minimizing cost variance and stabilized the participating suppliers' costs by signing five-year contract with partnered mills.

III. Aluminium Supply

Aluminium supply is not likely to be a major risk for Boeing. As aluminium was utilized in multiple industries, Boeing contributed less than 1% of the global aluminium demand. Additionally, the relationship between U.S domestic capacity and demand of aluminium indicated an evident increase in capacity as shown in Exhibit 3. Two mentioned conditions reveal that it is rarely to have a shortage of aluminium supply for Boeing.

Exhibit 3
Aluminum Capacity Analysis



Source: Created by the Tauber Institute using information from the 2016 U.S. Geological Survey Data Series (https://minerals.usgs.gov/minerals/pubs/historical-statistics/)

IV. Forecasting Model

Given the Aluminium Industry Production Capacity in Appendix A, we have access to the aluminium production, import, consumption, and other related data from 1991 to 2015. Total capacity is the sum of domestic production and import. To forecast the future capacity and consumption of aluminium, we could respectively build 2 types of time series model using the available data in hand: moving average model, exponential smoothing model.

Year	Primary Production	Secondary Production (old scrap)	Secondary Production (new scrap)	Secondary Production	Shipments	Imports	Apparent Consumption	Unit Value ($/t), in current dollars	Unit Value ($/t), in 1998 dollars	Per Capita GDP (2009)	Global Price of Energy Index (2005)
1991	4,121,000	1,320,000	969,000	2,290,000	6,350,000	1,280,000	4,830,000	1,310	1,570	$35,295	-
1992	4,042,000	1,610,000	1,140,000	2,760,000	6,850,000	1,460,000	5,450,000	1,270	1,480	$36,067	37.46
1993	3,695,000	1,630,000	1,310,000	2,940,000	7,330,000	2,230,000	6,310,000	1,180	1,330	$36,579	33.62
1994	3,299,000	1,500,000	1,580,000	3,090,000	8,170,000	2,990,000	6,480,000	1,570	1,730	$37,597	31.98
1995	3,375,000	1,510,000	1,680,000	3,190,000	8,260,000	2,550,000	5,880,000	1,890	2,020	$38,166	34.95
1996	3,577,000	1,570,000	1,730,000	3,310,000	8,330,000	2,410,000	6,210,000	1,570	1,630	$39,155	40.36
1997	3,603,000	1,530,000	2,020,000	3,550,000	8,880,000	2,630,000	6,260,000	1,700	1,730	$40,426	38.20
1998	3,713,000	1,500,000	1,950,000	3,440,000	9,260,000	3,050,000	6,590,000	1,440	1,440	$41,736	26.95
1999	3,779,000	1,570,000	2,120,000	3,700,000	9,840,000	3,390,000	7,160,000	1,450	1,420	$43,195	34.45
2000	3,668,000	1,370,000	2,080,000	3,450,000	9,830,000	3,290,000	6,890,000	1,640	1,550	$44,474	53.68
2001	2,637,000	1,210,000	1,760,000	2,970,000	9,300,000	3,240,000	5,720,000	1,520	1,400	$44,464	48.02
2002	2,707,000	1,170,000	1,750,000	2,930,000	9,620,000	3,600,000	5,850,000	1,430	1,300	$44,829	47.22
2003	2,703,000	1,070,000	1,750,000	2,820,000	9,710,000	3,690,000	5,680,000	1,500	1,330	$45,662	55.22
2004	2,516,000	1,160,000	1,870,000	3,030,000	10,400,000	4,180,000	6,060,000	1,850	1,600	$46,966	72.26
2005	2,481,000	1,080,000	1,950,000	3,030,000	10,500,000	4,850,000	5,990,000	2,010	1,670	$48,089	100.00
2006	2,284,000	1,580,000	2,800,000	4,380,000	10,500,000	4,660,000	5,690,000	2,680	2,160	$48,905	119.40
2007	2,554,000	1,660,000	2,450,000	4,120,000	9,720,000	4,020,000	5,170,000	2,690	2,120	$49,300	131.88
2008	2,658,000	1,500,000	2,130,000	3,630,000	8,530,000	3,710,000	3,940,000	2,660	2,010	$48,699	184.70
2009	1,727,000	1,260,000	1,570,000	2,820,000	6,840,000	3,680,000	3,320,000	1,750	1,330	$46,930	116.80
2010	1,726,000	1,250,000	1,540,000	2,790,000	7,720,000	3,610,000	3,460,000	2,300	1,720	$47,720	147.08
2011	1,986,000	1,440,000	1,670,000	3,110,000	8,520,000	3,710,000	3,530,000	2,560	1,860	$48,125	193.79
2012	2,070,000	1,630,000	1,760,000	3,380,000	9,080,000	3,760,000	4,130,000	2,230	1,580	$48,842	195.20
2013	1,946,000	1,630,000	1,790,000	3,420,000	9,450,000	4,160,000	4,530,000	2,080	1,450	$49,316	191.73
2014	1,710,000	1,700,000	1,880,000	3,570,000	9,960,000	4,290,000	5,070,000	2,300	1,590	$50,118	177.43
2015	1,587,000	1,470,000	1,910,000	3,380,000	10,400,000	4,560,000	5,220,000	1,940	1,340	$51,054	97.89

Source: Tauber Institute

Moving Average Model: Boeing could try different time window sizes, for example, 3-year average and 6-year average, and choose the model with the lowest MAD.

Exponential Smoothing Model: We recommend Boeing to use alpha that close to 1 (from 0.7 to 0.9) when building the model since the recent observations are more significant in terms of estimating the future capacity and consumption. Similar to the first model, Boeing could choose the best-performed model by comparing the MAD.

The final model will be the one with lower MAD that retrieved from 2 approaches. Intuitively, exponential smoothing model will be the more appropriate one as it could give a higher weighting to recent prices while the moving average model assigns equal weighting to all values. In this case, the recent observations are better predictor for the future capacity and consumption.

V. Titanium Supply

Titanium supply might be a major risk for Boeing because the aerospace is the largest driver of domestic titanium demand. Only three major titanium mills operated domestically, and Boeing contracted with two of them, indicating that "any disruption caused by natural disasters, geopolitical instability or macroeconomic events" will be costly and unbearable.

VI. Raw Material Mill Delivery Problem

Raw material mills do cause delivery problems, but they are very occasional. As mentioned in the case, "the communication errors led to significant delays in raw material delivery, as the orders had to be placed on hold pending approval or input from either Boeing or the supplier." In detail, miscommunication between raw material mills and Boeing or the supplier breeds late delivery. However, in line with the Exhibit 12, among 11865 late raw material deliveries, only 4 cases are caused by the Mills, indicating that the problem is quite occasional.

Exhibit 12
Late Raw Material Deliveries

Responsible Party	Late Raw Material Deliveries
Boeing	141 (1%)
Supplier	2,375 (20%)
Boeing/Supplier	290 (2%)
TMX	9,055 (76%)
Mill	4 (0.03%)

Source: Tauber Institute

VII. Weaknesses of Mill Risk Assessment Process

Under current Production Readiness Assessment (PRA) process, less than 1% questions were rated as non-green and not all the reported reasons represented an identified potential risk, including missing document, lean initiatives, and TMX forecast errors.

VIII. Revamp the Mill Risk Assessment Process

Given that lean initiatives were not a potential risk since they were unlikely to impact a mill's overall ability to support Boeing production, I suggest Boeing to delete the questions under lean metrics part to improve the mill risk assessment process.

As stated in the case, TMX was rated green for PRA categories associated with capacity in 2017 after being given a yellow rating the previous year because of "external sources in place to help with surge capacity." Apparently, TMX didn't resolve the surge capacity issue by using external sources and PRA process didn't accurately identify the potential risks as well. Though this problem was revealed under TMX risk assessment process, we can see something problematic associated with this assessment system. I recommend Boeing to precisely analyze the potential risks of their partnered companies rather than just write down some notes under the comments.

VIIII. Raw Material Mill Risk

Raw material mills are significant but unusual source of risks. In general, risks associated with Mill Production can be classified into 5 categories: Capacity Constraints, Mill Disruption, Aluminium and Titanium Industry Capacity Constrains, Geo-political Issues, and Quality and Delivery Challenges. Currently, the concerns of Boeing are about Titanium mill corruption caused by natural disasters and social events and aluminium industry's insufficient capacity. As both cases are minor events, I believe raw material mills are unusual source of risk for Boeing.

X.a TMX's Late Deliveries

Capacity issue is the key driver for 90% of late raw material deliveries caused by TMX and most of the identified capacity constraint is plate sawing process. In response to surge capacity, additional equipment for plate sawing process is recommended for Boeing. To timely identify the potential capacity constraint, Boeing could improve its PRA process since the PRA didn't capture the problem associated with plate sawing process in 2017 assessment.

X.b TMX's Inaccurate Forecast

Under-forecasting could lead to a shortage of raw materials supply or longer lead times, while over-forecasting results in financial losses, either through holding costs or contractual obligations. To resolve the inaccurate forecasts, Boeing upgraded the existing model by using the buy-to-fly ratios for three levels of production maturity as additional input. The improved model shows a more stable performance.

XI. Scrap Recovery

To calculate the total discounted opportunity value for next three years, I multiplied the recoverable scrap of each year and unit price of Titanium scrap since by 2017 almost all recoverable scraps have been collected. Considering the 8% discount rate, the total discounted opportunity value is $31824499.33 in 2017 dollars.

The scrap that not been collected by Boeing in 2016 is the difference amount between mill scrap commitment and scrap collected, therefore, the opportunity cost of non-collected scraps are $ 932599.17 in 2017 dollars.

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Discount Rate	0.08			
Unit Price of Titanium Scrap	0.75			
	2016	2017	2018	2019
Titanium Demand (pounds)	35,394,279	34,834,863	37,991,619	37,634,846
Total Scrap Available (pounds)	29,528,646	29,072,039	31,691,229	31,362,372
Mill Scrap Commitment (pounds)	13,648,754	12,900,000	1,260,000	1,190,000
Non-recoverable Scrap (pounds)	15,515,137	15,466,982	15,693,893	15,014,972
Recoverable scrap (pounds)	14,013,509	13,605,057	15,997,336	16,347,400
Scrap Collected (pounds)	14,800,111	13,605,057	15,997,336	16,347,400
Scrap Not Collected (pounds)		0	0	0
Titanium on Finished Products (pou	5,865,633	5,762,824	6,300,390	6,272,474
Opportunity Value	11100083.25	10203792.75	11998002	12260550
Discounted Opportunity Value		10203792.75	11109261.11	10511445.47
Total discounted opportunity value	31824499.33			
2016 Non-collected scraps	1,151,357	$ 932,599.17		