Business analytics: From problem solving to problem discovery
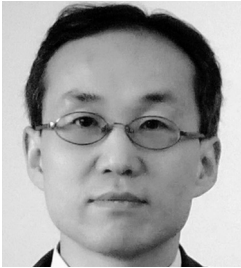
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Yao Zhao is a Professor in Supply Chain Management at Rutgers Business School and the co-director of Supply Chain Analytics Lab at Rutgers University. He holds a PhD degree in industrial engineering and management sciences in 2002 from Northwestern University. His research interests lie in supply chain management, analytics and healthcare. Yao has published in leading operations research and management journals such as *Operations Research*, *Manufacturing and Service Operations Management (M&SOM)*, *Production and Operations Management*, and served as an associate editor for *Operations Research* and *M&SOM*. Yao has consulted with companies and government agencies, such as General Motors, Estee Lauder, Verizon, MTA — NY Transit, Special Olympics, Johnson and Johnson, Fannie Mae, Defense Logistics Agency and US Navy, Korean Air-Cargo, Robert Wood Johnson hospitals and Water and Power Development Authority of Pakistan. His MIT System Design Management webinar on 787 Dreamliner (2013) attracted a worldwide attendance of 307 people from 29 countries and 50+ companies or organisations. Yao's work on the Special Olympics shuttle system helped the 2014 USA Games (5,000 athletes, 1,000 coaches and 11 locations in a 40-mile radius in NJ) to achieve 100 per cent customer satisfaction in transportation with a budget of US$600,000. His work on the Pakistan energy crisis proves the ineffectiveness of the government's then policy and suggests an alternative, which was partially adopted with a significant economic and social impact. Yao has launched a few popular courses on Coursera towards Supply Chain Analytics.

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Abstract

This paper provides a playbook for practitioners to discover problems and diagnose causes systematically using business analytics. Built on competitive intelligence and benchmarking, the practitioners' playbook presents a step-by-step procedure that tells managers which directions to look, what questions to ask, and what analysis (or actions) to take in each step, in order to identify the key challenges and opportunities for a company. We also challenge the conventional belief that problem discovery is less valuable and easier than problem solving by showing that it can be the other way around, using examples from the information technology, transportation and healthcare industries.

Keywords

problem discovery, business analytics, playbook, competitive intelligence, benchmarking, value chain.

INTRODUCTION

Analytics can be classified into four types (see Figure 1): from bottom to top, they are descriptive analytics to discover what happened, diagnostic analytics to access how it happened (that is, diagnose the causes), predictive analytics to predict what will happen next, and prescriptive analytics to develop an action plan for making things happen. Descriptive and diagnostic analytics are mainly about data-driven problem discovery while predictive and prescriptive analytics are mainly about model-driven problem solving.

Descriptive and diagnostic analytics clearly have a larger demand or user base than predictive and prescriptive analytics as practitioners are primarily concerned about problem discovery and cause diagnosis, because nothing in real life is well defined. Academicians, on the other hand, are more focused on solutions for well-defined problems. One reason, as Gartner[1] stated, is the belief that model-driven problem solving is more valuable
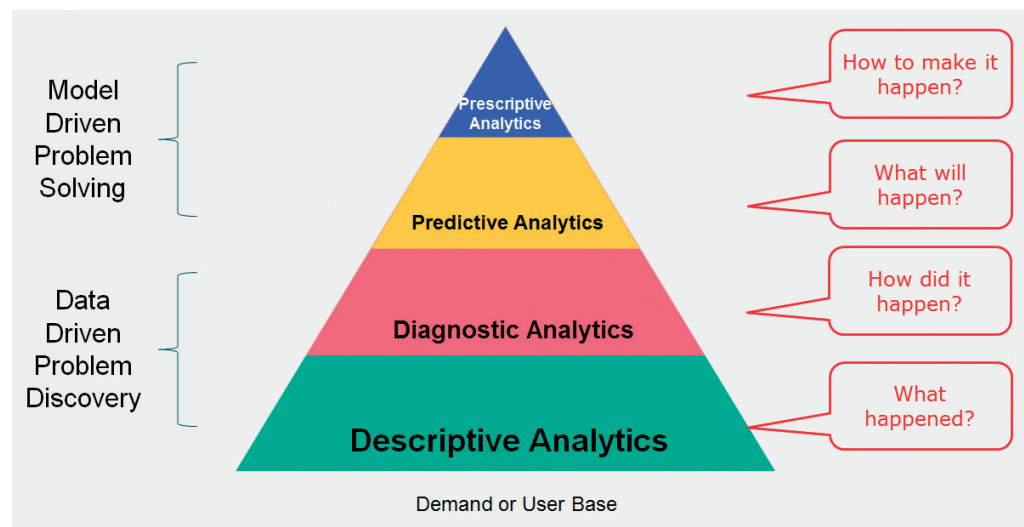

FIGURE 1 The four types of data analytics
Source: Authors

and more challenging than data–driven problem discovery. We, however, disagree with this belief and we are not the first. Albert Einstein once said:[2] 'If I have an hour to solve a problem and my life depended on the solution, I would spend the first 55 minutes determining the proper question to ask, for once I know the proper question, I would solve the problem in less than 5 minutes.' Steve Jobs said: 'If you define the problem correctly, you almost have the solution.' The point is clear: a sub–optimal solution to the right problem is better than the optimal solution to the wrong problem.

Using examples from various industries (IT, airlines and healthcare), this paper aims to achieve two objectives:

1. Demonstrate that problem discovery is not only more impactful but can also be more challenging than problem solving. It is just challenging in a different way;
2. Present a step-by-step playbook for practitioners to discover problems and diagnose the causes via business analytics — specifically, competitive intelligence and benchmarking.

THE VALUE AND CHALLENGE OF PROBLEM DISCOVERY

One of the key challenges in problem discovery is data interpretation, that is, how to transform data into business insights. Looking at the same data, different people may have different inter–pretations. The question is, do we really understand the data? Below we will use examples to showcase the value and challenge of data interpretation.

Compaq versus Dell

Until 2001, Compaq had been the market leader in the computer manufacturing industry with the largest market share, a healthy cash flow and many patents. To many people's surprises, Compaq sold itself to HP in 2002 for US$25bn. To understand Compaq's decision, we must first understand the computer industry background. Computer companies have the same key technologies and suppliers, such as CPU (Intel), operating system (Microsoft), etc. They were primarily competing on cost (and price) and customer services.

Table 1 shows the data which sheds some light on why Compaq sold itself. Compaq enjoyed a higher gross margin (23.18 per cent) than Dell (20.62 per cent). Compaq's operating cost (OC) over sales is higher (14.25 per cent) than Dell (10.08 per cent), however, because Dell operated (eg managed inventory) more effectively. Taking operating cost into account, Dell outperformed Compaq by about 1.5 per cent in operating margin. Why is this 1.5 per cent so critical that Compaq, the market leader, gave up the competition and sold itself?

To answer this question, we need to understand why Compaq has a higher gross margin than Dell in the first place. Gross margin is determined by two factors: total revenue and cost of goods

TABLE 1 Compaq versus Dell in 2000

Company	Gross margin	Inventory/sales	Inventory days	Operating cost/sales
Compaq	23.18%	5.32%	25.28	14.25%
Dell	20.62%	1.42%	6.53	10.08%

Source: Yahoo Finance

sold (COGS). Compaq's higher gross margin (than Dell) can be attributed to either a better deal from the suppliers (ie a lower COGS) or a higher price to customers (ie a higher revenue). As we mentioned before, computer companies had the same key suppliers, thus the difference in gross margins mainly came from different pricing. In fact, Dell priced its products 10–15 per cent lower than Compaq. Combining these findings leads to the following insight: *even with a lower price, Dell can make more profit, so how can Compaq compete?* The insight is clearly not seen by many people, including those in HP who bought Compaq. But Compaq's management saw it and made a wise decision on selling, which allowed them to salvage a huge value from a company with an inevitable destiny.

The Compaq versus Dell case is a classic example demonstrating the value and challenge of data interpretation. A more recent example is Taiwan Semiconductor Manufacturing Co.

(TSMC) versus Intel. Examining the data of gross and operating margins of semiconductor companies in the US and Taiwan from 2017 to 2019 (see Figure 2), we find that the financials of TSMC versus Intel resemble those of Compaq versus Dell back in 2000. Usually, a company with a higher gross margin also has a higher operating margin. But if we can find a counterexample, then we may discover another Compaq versus Dell case. Indeed, Figure 2 shows that Intel (INTC) had a higher gross margin (ie a higher pricing) but a lower operating margin than TSMC. We must point out the difference between computers and semiconductors because computer manufacturers share the same key technologies, but semiconductor companies are differentiated by technical innovations. Thus, Intel may not be another Compaq. That said, TSMC clearly operated more efficiently than Intel, which can be a substantial advantage and one of the reasons for the US government to invite TSMC to America in 2020.
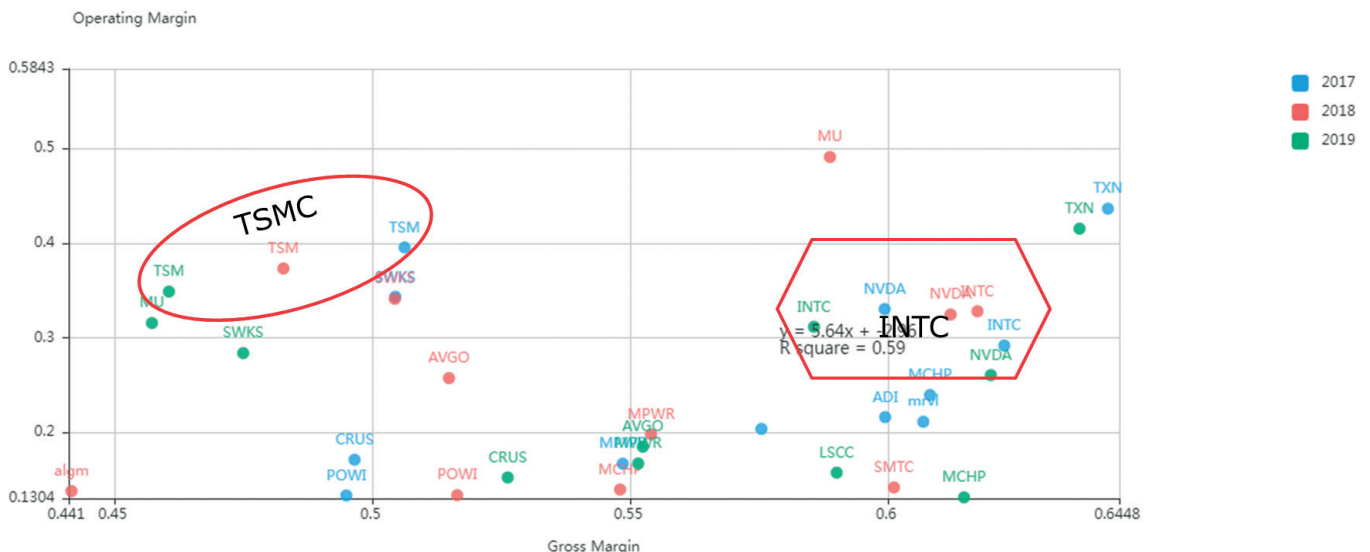

FIGURE 2 TSMC versus Intel in the US and Taiwan semiconductor industry
Source: SCDATA[3]

Healthcare

Outsourcing is a decision under heavy debate in the US healthcare sector, especially during the COVID-19 pandemic. Challengers cited the supply chain disruptions and the resulting shortages, but supporters argued about the benefits such as cost reduction.

To see whether outsourcing is a viable decision, we consider three groups of healthcare companies: biotechnology, healthcare equipment and supplies, and pharmaceuticals. As we shall see, outsourcing decisions can be different for different groups. Figure 3 shows the revenue breakdowns for these groups in the US in 2019. Clearly, US healthcare equipment and supplies group has a cost structure close to a manufacturing company with COGS accounting for 43 per cent of the revenue, selling, general and administrative expenses (SG&A) 34 per cent and net margin 11 per cent. It makes sense to outsource raw materials for this group because savings in COGS may outweigh the additional

cost in SG&A (outsourcing may increase SG&A expenses due to a longer supply chain and challenges in administrating suppliers). US pharmaceuticals, on the other hand, has a different cost structure with COGS accounting for 30 per cent of revenue, SG&A 26 per cent and net margin 20 per cent. Outsourcing raw materials for US pharmaceuticals may not bring a net cost reduction because SG&A expenses are almost as important as COGS. Outsourcing is an even less viable option for US biotechnology which has an average COGS 18 per cent of the revenue but SG&A 34 per cent. Thus, outsourcing raw materials is unlikely to achieve a net cost reduction for US biotechnology, but may only bring a higher supply risk and total cost.

Value and challenge of problem discovery

These examples demonstrate the value and challenge of data interpretation to extract business insights for strategic
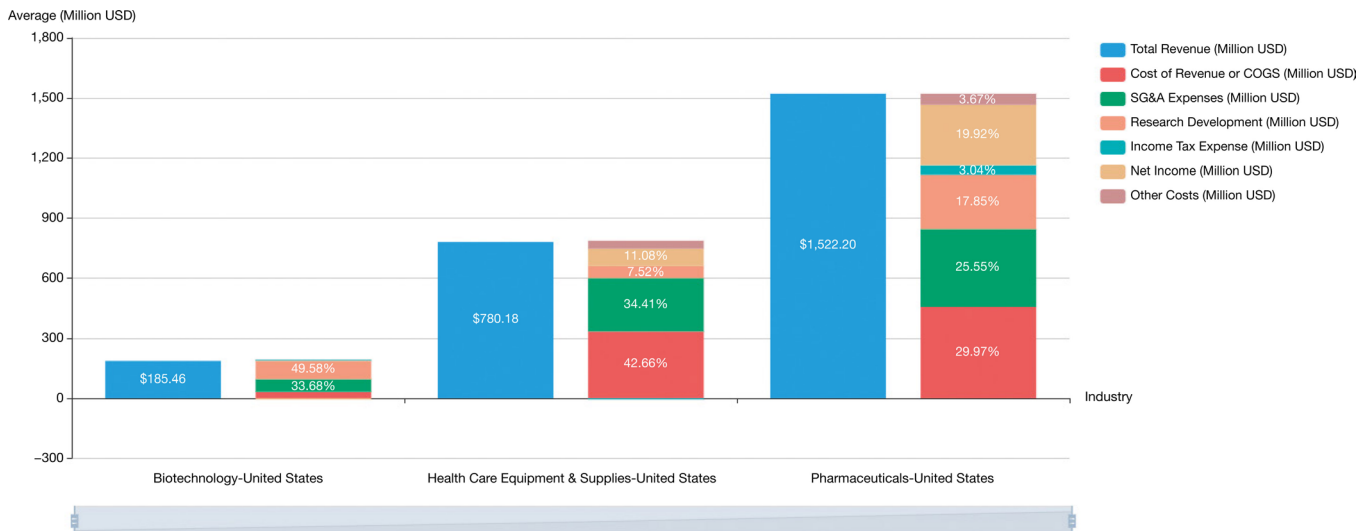

FIGURE 3 Biotechnology, healthcare equipment and supplies, pharmaceuticals
Source: SCDATA[4]

decisions on merger and acquisition (M&A) and outsourcing. These insights can be hard to derive without years of experience and industry knowledge. Our question is, is there a systematic way to extract business insights from data on a regular basis?

After discovering and solving many problems in practice, we find certain patterns in data analytics which can be formulated into a systematic way, a playbook, for problem discovery. The playbook lays out a business analytics process, based on competitive intelligence and benchmarking, that tells management which directions to look, what questions to ask and what analysis (or actions) to take in each step, to identify the key challenges and opportunities for a company.

BUSINESS ANALYTICS: A PRACTITIONER'S PLAYBOOK

One of the most important management skills is to see the big picture by answering questions, such as, what are the biggest challenges and opportunities of this company? Which direction(s) should we head in? In fact, a typical management consulting project starts with these questions to discover and prioritise problems. The business analytics playbook provides a powerful tool to answer these questions systematically by benchmarking the industry, the supply chain and competition. The playbook consists of the following phases:

1. *Industry analysis*: This phase compares the focal industry to related industries using analysis tools such as industry trend analysis, concentration and competition intensity and value chain analysis, to assess the potential, trend and risk of the focal industry;

2. *Competition positioning*: This phase compares the focal company to its peers in the focal industry using analysis tools such as profit frontier, enterprise ranking and key performance indicators (KPI) examination, to position the focal company in the competitive landscape;

3. *Enterprise diagnosis*: This phase compares the focal company to selected competitors using analysis tools such as strengths and weaknesses, value driver analysis and breakdown analysis, to discover problems and diagnose causes for the focal company.

The playbook helps answer the following questions:

- What are the trends, market potential and risk of the industry?;
- Should I focus on my core business or expand up or down streams?;
- Where do I stand in the competitive landscape?;
- What are my strengths and weaknesses relative to my competitors?;
- What factor(s) may drive a company's financial performance in my industry?;
- What are my key problems and the causes?

We shall elaborate the playbook step-by-step through the example of American Airlines (AAL) in the US airlines industry. By the end of 2022 (see Figure 4), it is clear that AAL, one of the world's largest airlines and a SP500 company, is in trouble. With the growth rate of its stock price dropped far below other major US airlines, AAL needs to find out what is going on and how to turn the company and its stock price around. Indeed, the whole airlines industry seems in trouble and has not yet recovered from the COVID-19

pandemic. Addressing the challenges faced by AAL and the airlines industry may well be a large-scale management consulting project. To start, competitive intelligence is required to discover the problems and opportunities that lay the foundation for turning-around strategies.

Phase 1: Industry analysis: Assessing industry potential and risk

Phase 1 consists of three steps: industry trend analysis, concentration and competition intensity and value chain analysis.

Step 1: Industry trend analysis

Industry trend analysis helps companies understand time patterns that occur in a specific industry.[5] The results can be used to assess the potential and risk of an industry.

Questions
- What are the trends, market potential and risk of the industry? For instance, is this a sunrise or sunset industry?;
- Are there economic or environmental factors that could affect the industry as a whole?

Actions
Compare industries by size, profitability, financial health and growth over time.

Example: Airlines, air freight and airport services
The trend analysis on the industry total size (see Figure 5) shows that air freight and airlines are much bigger than airport services in total revenue and they were constantly growing until 2020 when air freight accelerated its growth, but airlines plummeted in both revenue and profits due to COVID-19. In fact, almost all airlines and airports lost money in that year. In 2021, both airlines and
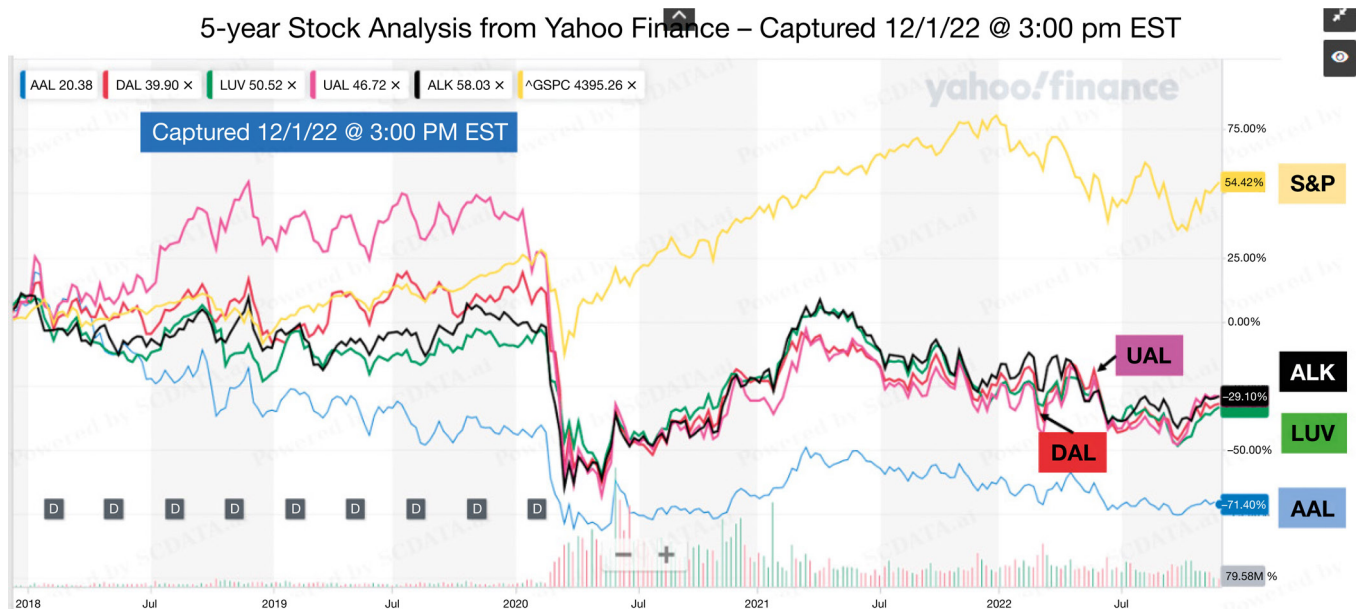

FIGURE 4 Five-year stock price changes ending 12/2022
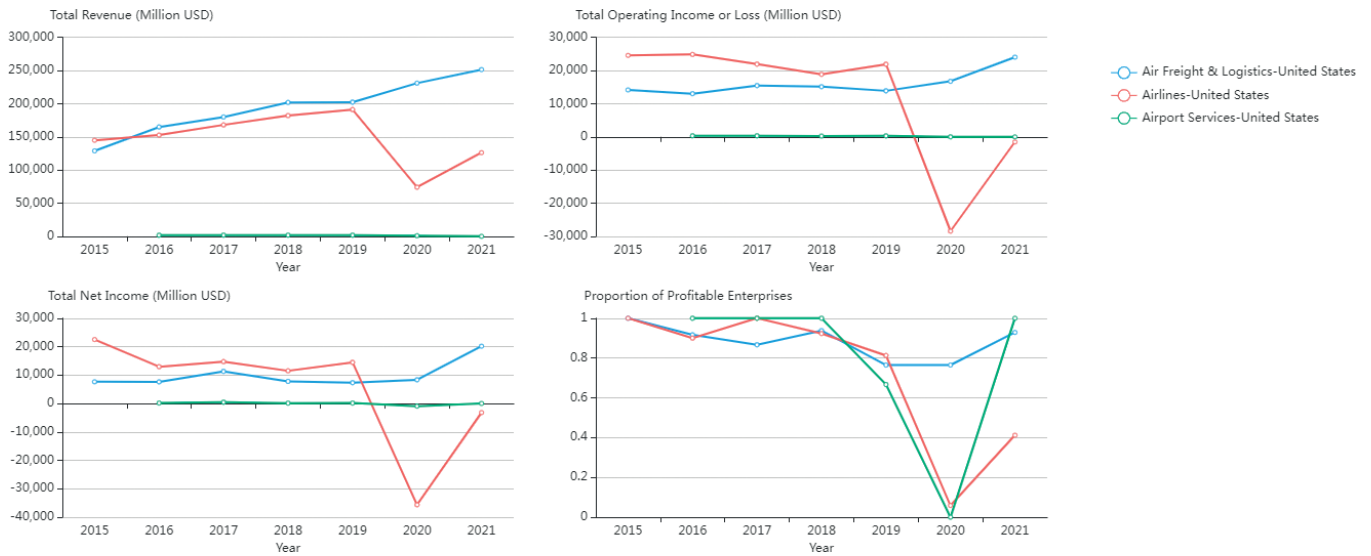Source: Yahoo Finance

FIGURE 5 Comparing airlines, air freight and airport services by size
Source: SCDATA[6]

airport services industries bounced back but were not yet fully recovered; air freight continued to grow and clearly enjoyed a higher profit than the airlines and airports.

The industry trend analysis on profit-ability (see Figure 6) confirms our observations and further shows that airport services, although quite small, has the highest gross margin and compa-rable operating and net margins to the airlines, which is better (2×) than air freight before 2020. COVID-19 is detri-mental to both airlines and airports,

FIGURE 6 Comparing airlines, air freight, and airport services by profitability
Source: SCDATA[7]

however; only air freight is not negatively affected.

Figure 7 provides a comparison of financial health for air freight, airlines and airport services, which shows that airport services have a higher current ratio and a lower liability asset ratio than air freight and airlines, indicating a better financial health. Air freight and airlines, however, are much larger and have more operating cash and total cash than airport services, providing both with a better path to improved financial health.

In summary, air freight proved to be the steadier of the three (air freight, airlines, airport services), enjoyed a consistent and highest growth in revenue and profits before and during the COVID-19 pandemic. Airlines are more profitable than air freight with higher gross and net margins before the pandemic; however, airlines are more susceptible to risks such as pandemics. Despite being the smallest in size, airport services enjoy the highest gross margin and are in better overall financial health

among the three, although it is also vulnerable to pandemics.

Step 2: Concentration and competition intensity

Concentration and competition intensity measures the competitiveness of an industry by the concentration (market share) of the largest companies. According to Porter,[8] competition intensity deter–mines the profitability of an industry and the competitive forces that drive a company's strategy.

Questions
• Is this a monopolised or competitive market?;
• Can small companies survive and thrive in this industry?

Actions
Analyse the industry by:

1. *Market share analysis*: If the market is concentrated on a few dominant

FIGURE 7 Comparing airlines, air freight and airport services by financial health
Source: SCDATA[9]

players, it is likely a monopolised market where small companies cannot survive. On the other hand, if there are many small companies accounting for a significant portion of the market share, then it is a competitive market where small companies can survive and thrive;

2. *Four company concentration ratio*: The market share of the largest four companies over time. If the ratio is close to 100 per cent, then it is a monopolised market. The trend of the ratio indicates whether industry is becoming more or less concentrated.

Example: Airlines, air freight and airport services
Market share analysis
The US airlines, air freight and airport services are quite monopolised with a significant portion of market share taken by the largest companies. Comparatively, however, the magnitude of monopoly is different among them. By Figure 8, the

airlines were the least concentrated (ie monopolised) of the three with the top four airlines making up nearly 80 per cent of the industry's total revenue. The air freight industry was more concentrated than airlines (top four represent nearly 90 per cent of the industry revenue) but less concentrated compared to airport services (see Figure 9). Airport services were the most concentrated industry of the three (see Figure 10).

Four company concentration ratio
By Figure 11, airport services are more concentrated (less competitive) than air freight and airlines. In addition, the US air freight industry has become more concentrated, but the airline industry became less concentrated after the pandemic. Note that not every airport, airline and air freight are publicly traded, so the analysis results should not be understood literally, only the comparative insights make sense.

In summary, air transportation related industries are quite concentrated, that is,
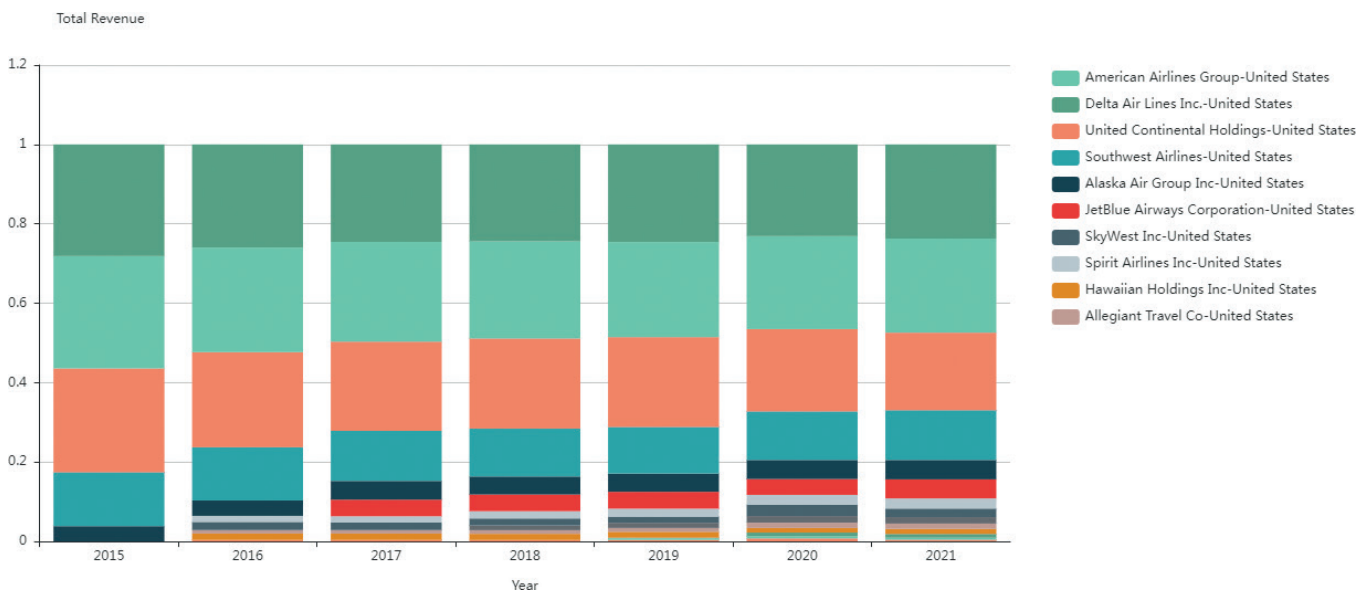
Total Revenue

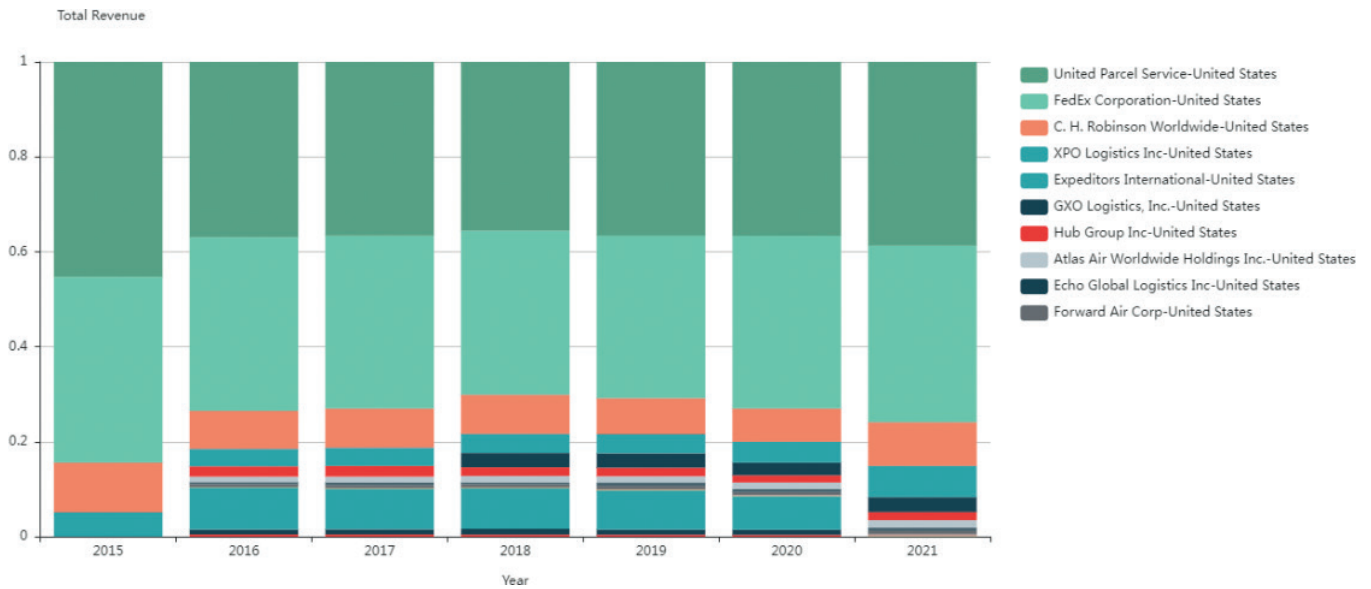**FIGURE 8** Market share analysis of US airlines
Source: SCDATA[10]

Total Revenue

FIGURE 9 Market share analysis of air freight
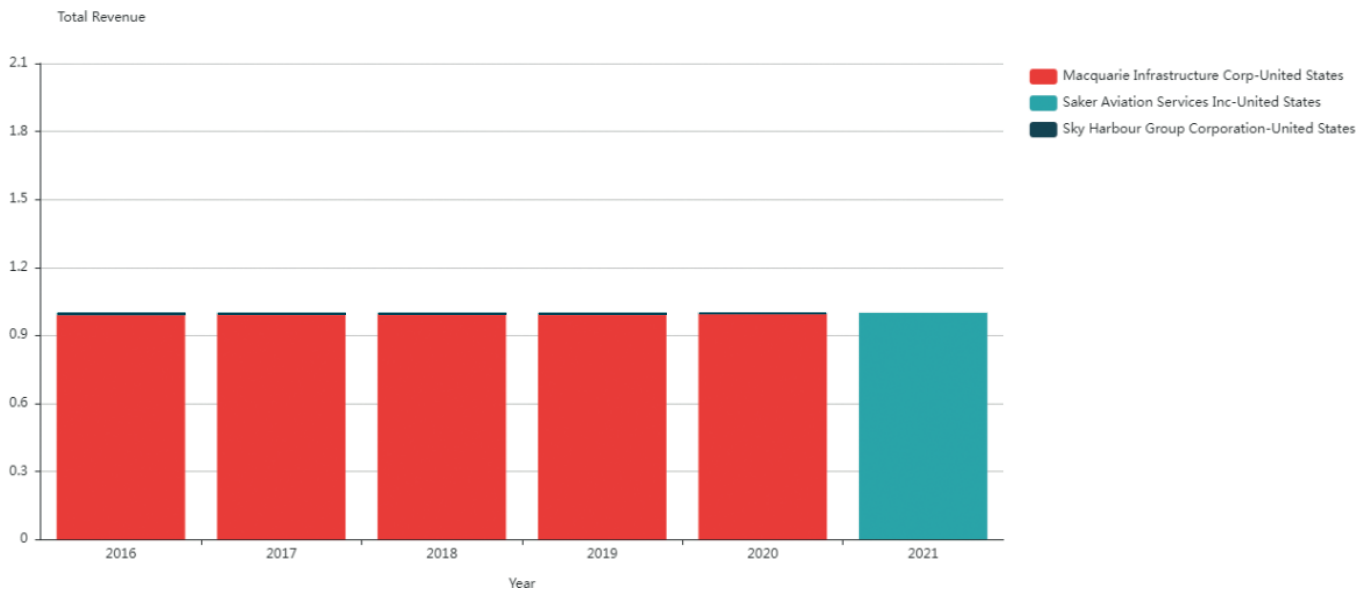Source: SCDATA[11]

Total Revenue

FIGURE 10 Market share analysis of airport services
Source: SCDATA[12]

these industries have most of the market share taken by a few large companies, and small companies may find it hard to survive and thrive. Overall, airport services is the most concentrated (or monopolised) industry while airlines is the least. In addition, the airlines industry is becoming less concentrated, but air freight is becoming more concentrated after the pandemic.
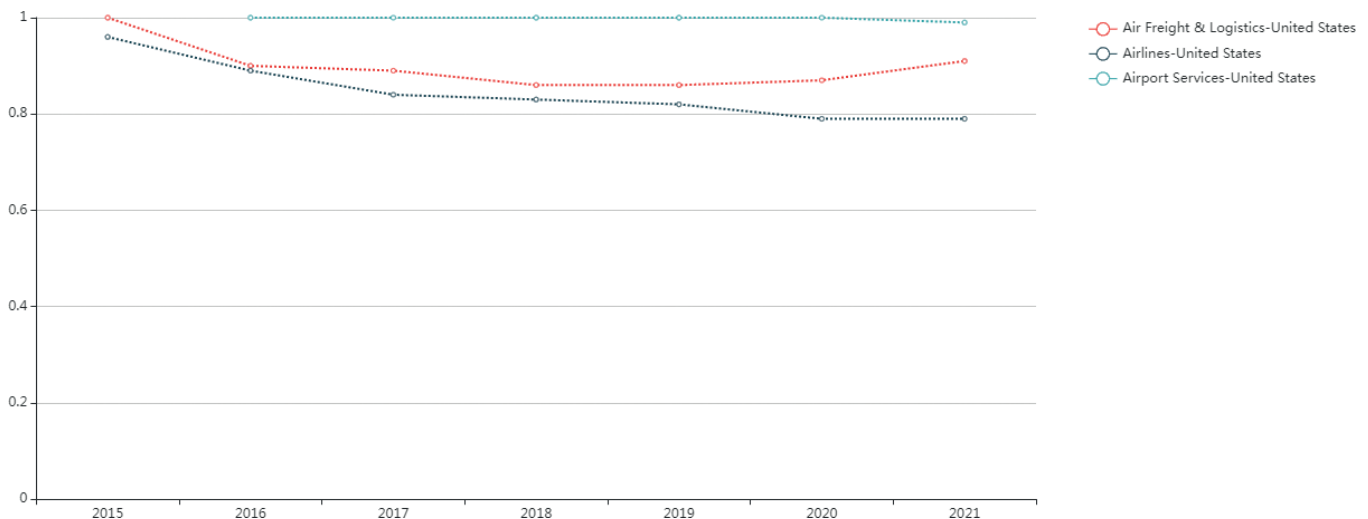
FIGURE 11 Four-company concentration ratio of air freight, airlines and airport services in the US
Source: SCDATA[13]

Step 3: Value chain analysis

The importance of value (supply) chain has been recognised especially after the COVID-19 pandemic. Value chain analysis is a process to identify problems and opportunities along the supply chain for expansion, acquisition and risk reduction.

Questions
• What are the most valuable (eg most profitable) segments of my supply chain?;
• Should we expand our business upstream or downstream?

Actions
Compare industries along the supply chain by profitability, growth and financial health via supply chain mapping and industry comparison.

### *Example: Supply chain mapping of the airlines industry*
The airlines supply chain consists of airlines, airport services, aerospace and defence, oil and gas supplies and so on (see Figure 12). Due to the limited space, we shall focus on supply chain mapping in this step. A supply chain mapping analysis provides a snapshot of the most profitable segment along the supply chain. In the US, Figure 12 indicates that airport services and oil and gas exploration and production are most profitable along the airlines supply chain, with airlines being the least (negative). On a global scale, oil and gas exploration and production is also the most profitable segment, while airlines are the least profitable (see Figure 13). In both cases, airport services outperformed airlines in profitability partially due to a more concentrated and less competitive market (Step 2).

In summary, airports outperformed airlines both globally and regionally (US) in terms of profitability and financial health. Thus, an airline may expand its business to airport services. Airlines and airfreight companies may join hands to achieve a better balance over risk versus profitability and growth.
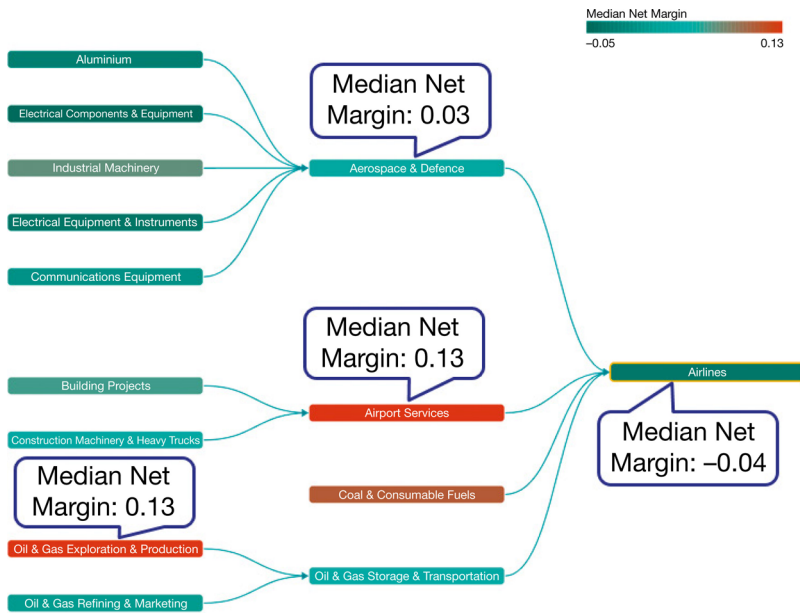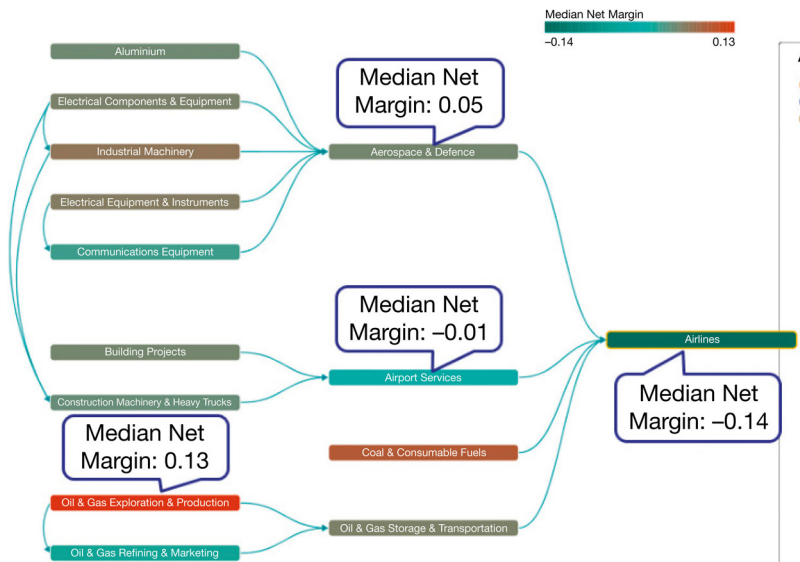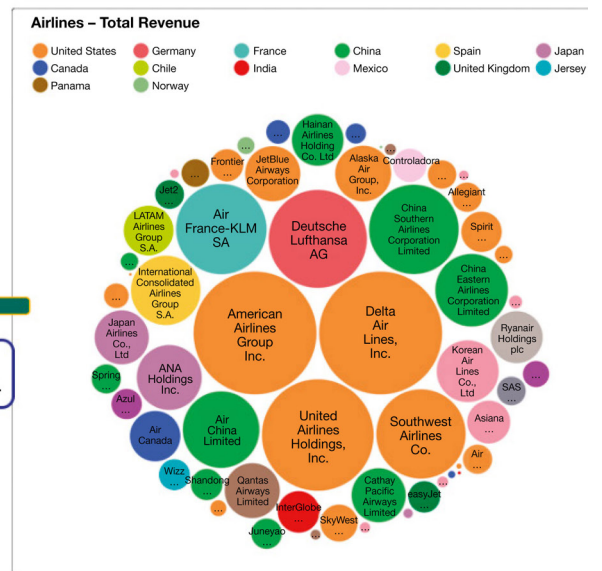
US Airlines Supply Chain 2021
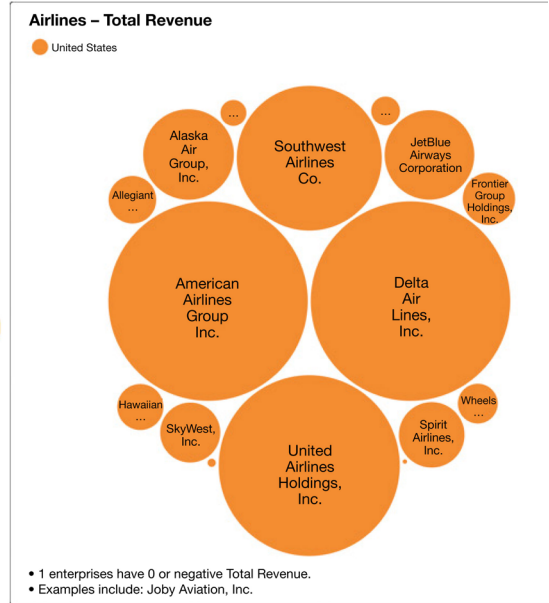
US Airlines 2021

FIGURE 12 Supply chain mapping on net margin (US 2021)
Source: SCDATA[14]

Global Airlines Supply Chain 2021

Global Major Airlines 2021

FIGURE 13 Supply chain mapping on net margin (Global 2021)
Source: SCDATA[15]

Phase 2: Competition positioning: Positioning a company in the competitive landscape

Phase 2 consists of three steps: profit frontier, enterprise ranking and KPI examination.

Step 1: Profit frontier

The profit frontier represents a set of analysis tools to identify the most profitable and competitive companies in one industry. This is one of the best ways to position a company in the competitive landscape of profitability and risk.

Questions

- What are the most profitable and competitive companies in this industry?;
- Where does the focal company stand in the competitive landscape?

Actions

Position companies on maps of:

- Operating margin versus total revenue;
- Return on asset (ROA) versus liability asset ratio;
- Total revenue versus total cost;
- Operating income versus total cost or total assets.

Example: Airline industry

We first position AAL on the operating margin versus total revenue map (see Figure 14) to identify the profit frontier for the US airlines. Typically, you will observe a declining operating margin as the revenue increases because revenue is the denominator of operating margin. We can see that Delta (DAL) is on the profit frontier but United Continental Holdings (UAL) and AAL are below it. In fact, AAL is the worst performer in its revenue class composed of DAL, UAL and AAL. Southwest (LUV) is also on the profit frontier, indicating its competitiveness.

Let us now position AAL on the return versus risk map of the US airlines (see Figure 15). This graph provides interesting insights: (1) AAL's liability
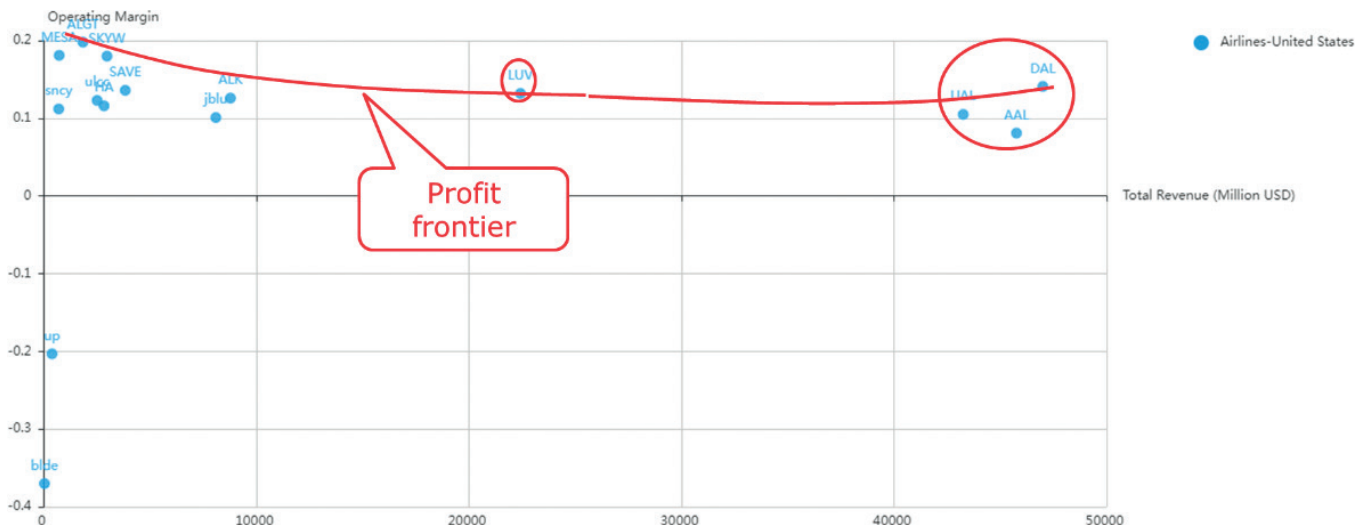

FIGURE 14 Operating margin versus total revenue for US airlines 2019
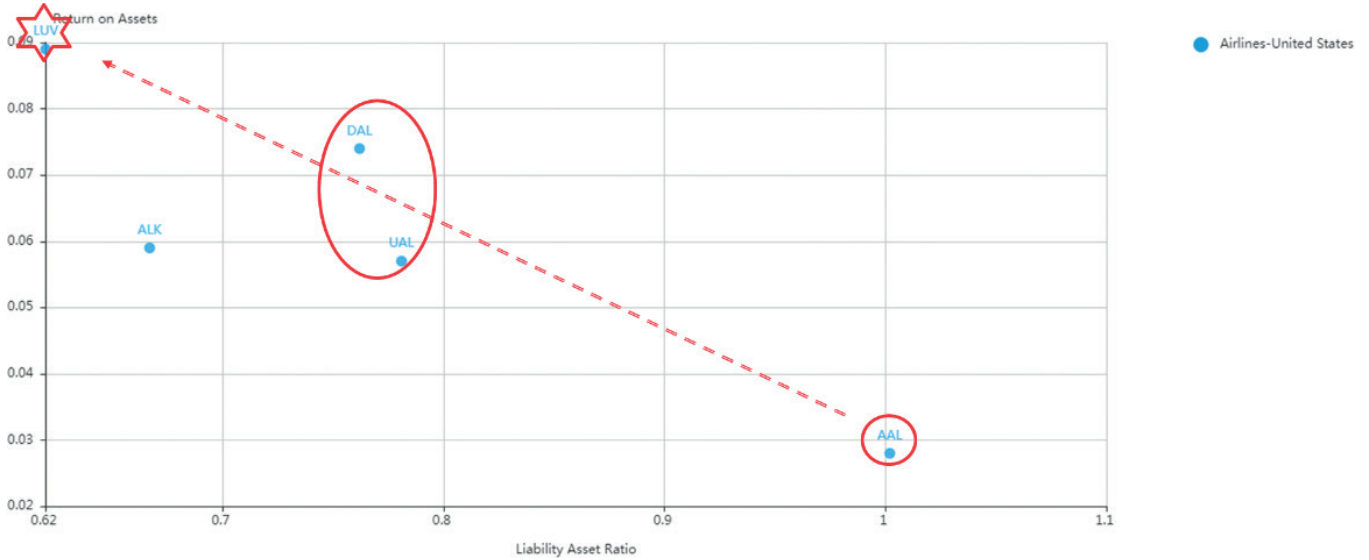Source: SCDATA[16]

FIGURE 15 Return on asset versus liability asset ratio (return versus risk) US airlines SP500 companies 2019
Source: SCDATA[17]

asset ratio is above 1, which means that the company's liability is already greater than its assets in 2019; (2) AAL has the lowest ROA among all US airlines, even below Alaska (ALK) airlines. DAL and UAL had about the same liability asset ratio, but DAL's ROA is much higher;

(3) LUV has the least liability asset ratio but the highest ROA. In summary, AAL performed the worst on both ROA and financial health, and LUV is the best, while DAL and UAL are in between.

Figure 16 shows the total revenue versus total cost map for the top five US airlines.
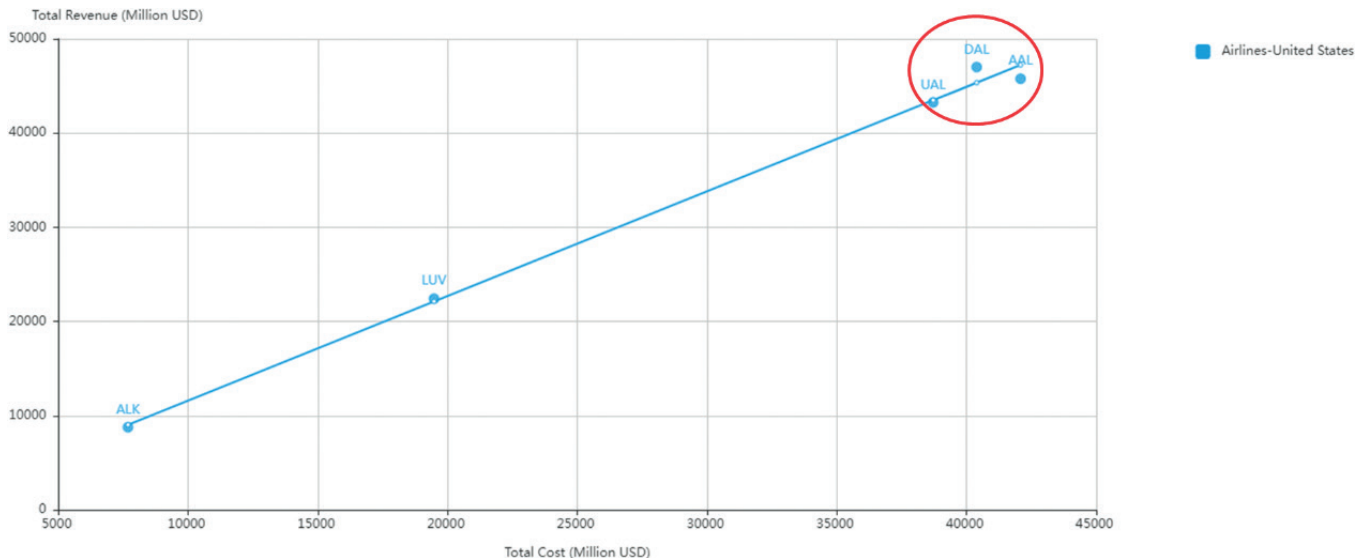

FIGURE 16 Total revenue versus total cost US airlines 2019
Source: SCDATA[18]

Clearly, AAL is one of the largest three US airlines, and DAL made a higher revenue than AAL and did so with less total cost. LUV and ALK are smaller in size and clearly not in the same league as AAL.

To better see the difference in profit–ability, we plot the graph of operating profit versus total assets (see Figure 17). AAL has the lowest operating income in comparison to DAL and UAL with about the same assets. In particular, UAL achieved a higher operating income with less assets than AAL. LUV has less than half of AAL's assets but achieved an operating income only slightly lower than AAL, implying LUV's efficiency in assets utilisation.

In summary, AAL is one of the largest airlines in size but has the lowest operating income and the highest liabilities among its peers. Comparatively, DAL is the largest in size, highly profitable and also bears less liabilities; LUV is smaller in size but one of the most profitable airlines and carries the least liabilities. Overall, the results show that LUV and DAL are among the most competitive airlines, and AAL has huge room for improvement on profitability and financial health.

Step 2: Enterprise ranking

Enterprise ranking examines a company's placement among other companies using varied metrics. It is one of the most intuitive ways to compare companies side-by-side.

Question
• Where is the company ranked relative to its competitors?

Actions
Rank companies by:

• Total revenue;
• Operating margin;
• ROA.

Example: Airline industry
AAL is the second-largest airline in the US in 2019 by total revenue, DAL is the
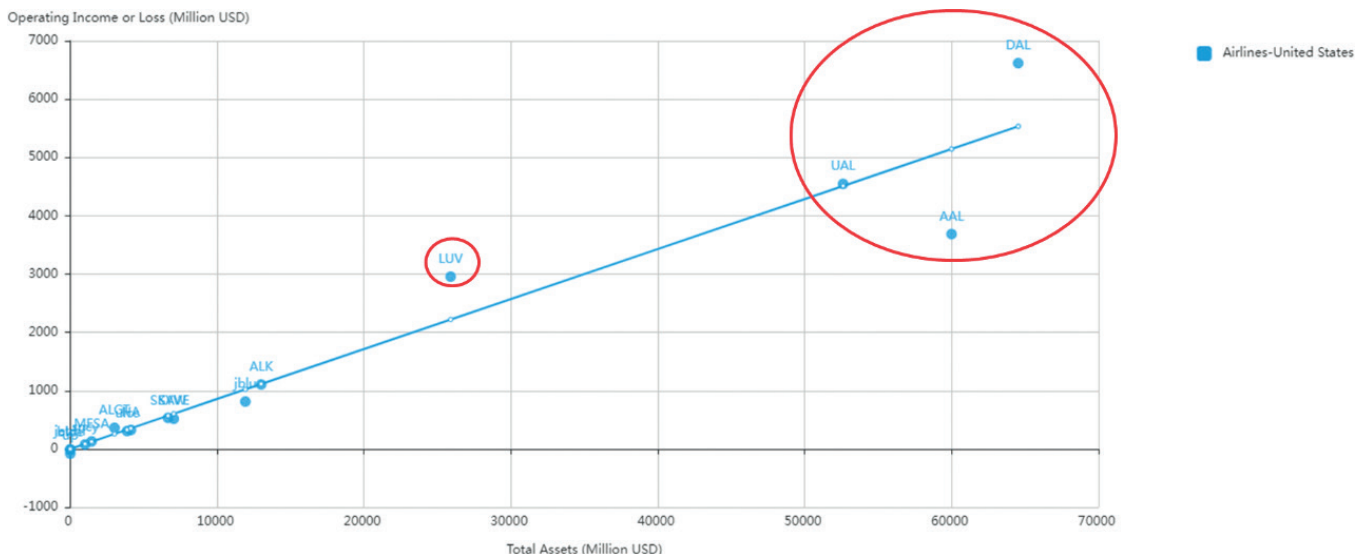

FIGURE 17 Operating profit versus total assets US airlines 2019
Source: SCDATA[19]

largest, UAL is slightly smaller, LUV is half the size of AAL, and ALK is about 1/5th the size of AAL (see Figure 18).

AAL ranked last in operating margin, DAL and LUV ranked the highest (see Figure 19). AAL also ranked the last in ROA while LUV and DAL ranked the highest (data is not shown here).

Combining enterprise rankings from various metrics, we can clearly see that

Enterprise Ranking – Total Revenue (Million USD)
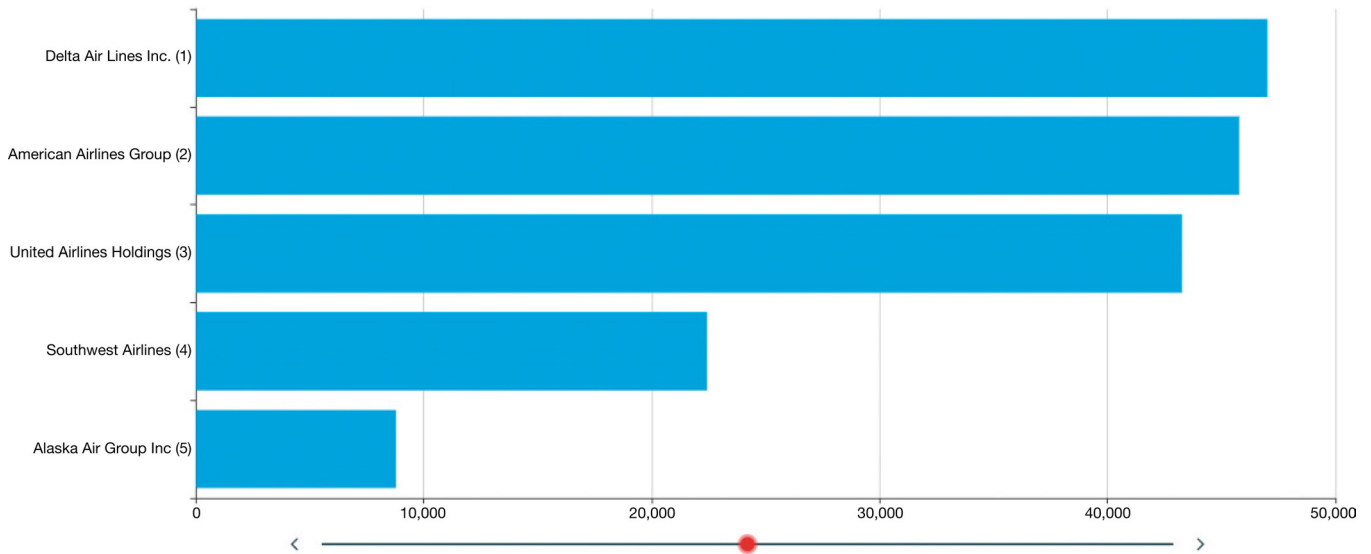

FIGURE 18   Total revenue ranking US airlines SP500 Companies 2019
Source: SCDATA[20]

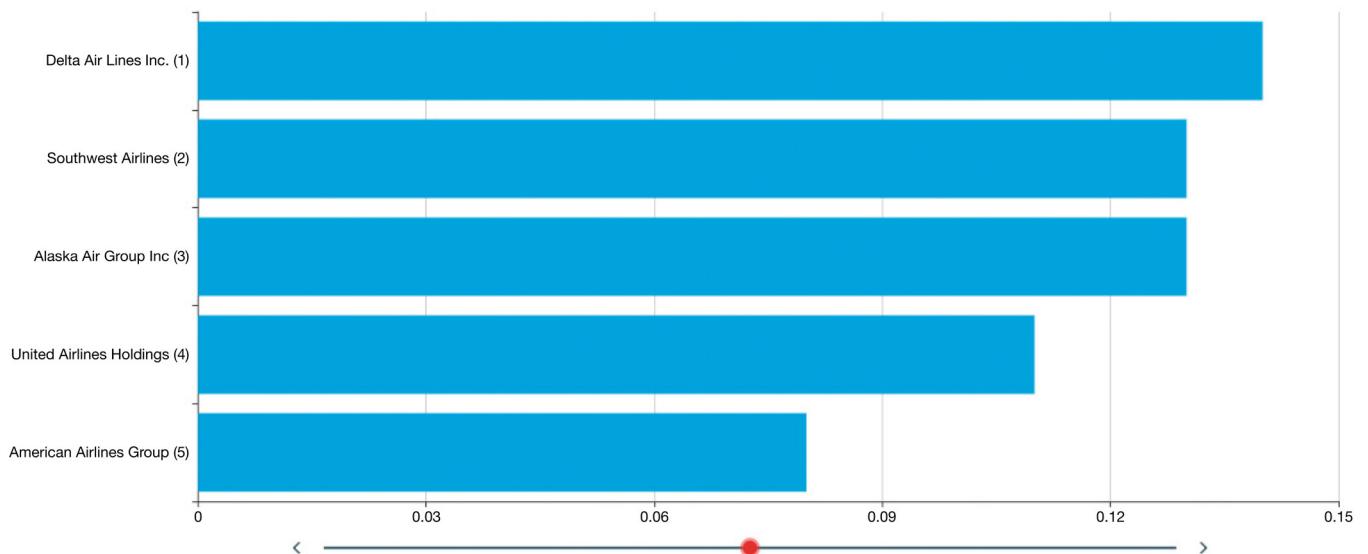**Enterprise Ranking – Operating Margin**

FIGURE 19   Operating margin ranking US airlines SP500 companies 2019
Source: SCDATA[21]

AAL is one of the largest but least profitable airlines in the US, consistent to our previous analysis in profit frontier. On the other hand, DAL is an overall solid airline as it ranks highest in total revenue and operating margin and second in ROA. LUV, much smaller in size, performed exceptionally well in all three categories, especially in ROA where it was the best.

Step 3: KPI examination

KPIs measure by how much a company achieves the intended goals.[22] Similar to the physical examination of a person, KPI examination of a company provides a comprehensive assessment of the company's performance in profitability, financial health, growth and operational efficiency relative to its peers, for the purpose of detecting abnormalities and signalling early alarms for potential issues. This is done by assessing the company's performance (eg percentile rank) in contrast to its peers (the population) in the same industry.

Questions
- Where am I positioned among peers in the same industry?;
- Do I have any abnormalities or potential issues undetected?

Actions
Compare companies by:

1. Enterprise comparison on KPIs;
2. KPI examination.

Example: AAL
Due to limited space, we shall skip enterprise comparison on KPIs and move directly into KPI examination. Figure 20 shows the KPI examination of AAL relative to its peers in the US

airlines industry. Let us focus on the abnormal KPIs (in red boxes) for which the percentile rank of AAL is either below 25 per cent (low) or above 75 per cent (high). We first look at profitability, despite its normal gross margin, AAL's operating margin, net margin and ROAs are low in the industry, implying low profitability. For financial health, AAL has a high liability asset ratio which is above one, indicating its inability to pay long-term debts and thus, poor health. Regarding growth, except for a normal total revenue growth, the growth rates in operating income and net income are low, implying slow growth among its peers. For operational efficiency, AAL has a fine operating cost over revenue ratio, but its inventory days are on the high side, indicating a mixed operating efficiency.

In summary, AAL is underperforming in all but one of the dimensions (that is, profitability, financial health and growth) relative to other US airlines, indicating serious issues in operating the company and a need for change in AAL's overall business strategies.

Phase 3: Enterprise diagnosis: Discovering problems and diagnosing causes
Phase 3 consists of three steps: strengths and weaknesses, value driver analysis and breakdown analysis.

Step 1: Strengths and weaknesses
Understanding a company's strengths and weaknesses relative to its competitors can provide crucial information on what is working well and what is not (potential problems) for the company.

Class	The Value of American Airlines Group	The Percentile Rank of American Airlines Group		90th Percentile	3rd Quartile (75th Percentile)	Median	1st Quartile (25th Percentile)	10th Percentile	Status	Unit
Profitability										
Gross Margin	0.227	0.38		0.3	0.27	0.26	0.22	0.14	Normal	
Operating Margin	0.88	0.19	Low	0.19	0.14	0.12	0.1	–0.27	Low	
Net Margin	0.036	0.19		0.12	0.1	0.08	0.07	–0.29	Low	
Return on Assets	0.028	0.13		0.08	0.07	0.05	0.04	–11.16	Low	
Return on Invested Capital	0.069	0.21		0.26	0.16	0.12	0.07	0.05	Low	
Financial Health										
Free Cash Flow / Total Cost	–0.011	0.29		0.14	0.06	0.04	–0.04	–0.45	Normal	
Current Ratio	0.448	0.27		1.08	0.82	0.65	0.44	0.31	Normal	
Liability Asset Ratio	1.002	0.87	High	2.2	0.8	0.71	0.67	0.61	High	
Growth										
Total Revenue Growth Rate	0.027	0.31		0.16	0.09	0.06	0.02	0.05	Normal	
Operating Income Growth Rate	0.08	0.23	Low	1.8	0.47	0.18	0.09	0.07	Low	
Net Income Growth Rate	0.194	0.23		2.1	1.05	0.42	0.2	0.06	Low	
Free Cash Flow Growth Rate				26.71	3.2	0.89	–0.07	–3.96		
Operational Efficiency										
Sales General Admin Cost / Total Revenue	0.035	0.07	Mixed	0.37	0.07	0.05	0.04	0.04	Low	
Inventory Days	19.096	0.92		18.88	14.04	9.86	4.15	3.68	High	day
Cash Conversion Cycle	–26.177	0.71		–21.86	–25.7	–37.45	–41.32	–50.13	Normal	day

FIGURE 20   KPI examination of AAL 2019
Source: SCDATA[23]

Question
• What are my strengths and weaknesses relative to my competitors?

Actions
Compare companies by size, profitability, and financial health via:

• Enterprise trend analysis;
• Enterprise comparison.

Example: AAL
Size
For AAL and selected competitors, such as, DAL, UAL, LUV, ALK, we performed an enterprise trend analysis first on size, which shows that over the period of 2015–21, the total revenues of these airlines kept increasing until the pandemic, then plummeted during the pandemic, finally bounced back post-pandemic. The operating incomes of these airlines were either stable or slightly declining even before pandemic pre-pandemic, and AAL (in blue) had the sharpest decline and the smallest rebound (see Figure 21).

Profitability
Figure 22 shows that every airline lost money in 2020 due to COVID-19; however, LUV, ALK, and DAL were able to recover in 2021 in every metric. AAL proves to be a different story as they were not able to fully recover indicating fundamental financial issues that need to be resolved. Figure 23 highlights these insights for 2021 and one can clearly see the gap between AAL and its peers.

Financial health
The enterprise trend on financial health shows that the airlines have high and increasing liability asset ratios; and among
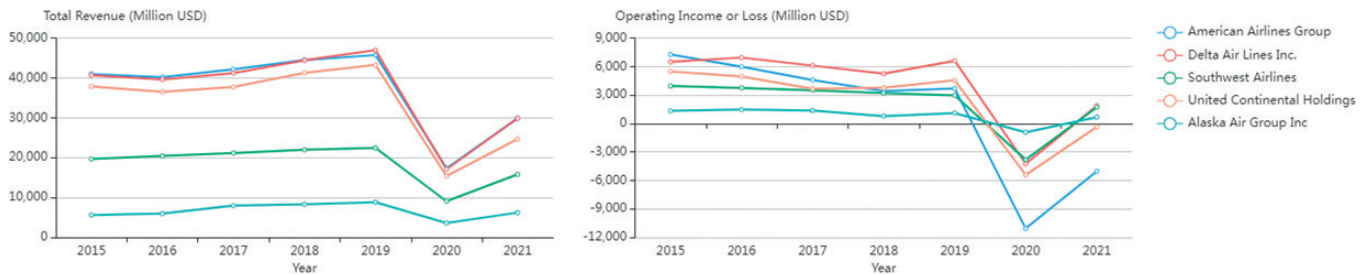
FIGURE 21 Total revenue and operating income airline comparison (trend)
Source: SCDATA[24]

FIGURE 22 Airline profitability comparison
Source: SCDATA[25]

them, AAL has the highest liability asset ratio consistently during these years and approaching and exceeding 1 in 2020 which is the danger zone (see Figure 24). AAL (in blue) also has a significantly higher long-term debt ratio than other airlines.

In summary, AAL was weakest in nearly all metrics of profitability and financial health among major US airlines and was highest in liability assets and long-term debt ratios. AAL's strengths are its high revenue and gross margin. The analysis of strengths and weaknesses shows that AAL has the potential but needs to address its problems quickly.

Step 2: Value driver analysis

Value driver analysis can be used to identify the drivers and levers that may directly affect the company's performance metrics.

Questions

- What factor(s) may drive a company's financial performance in my industry?

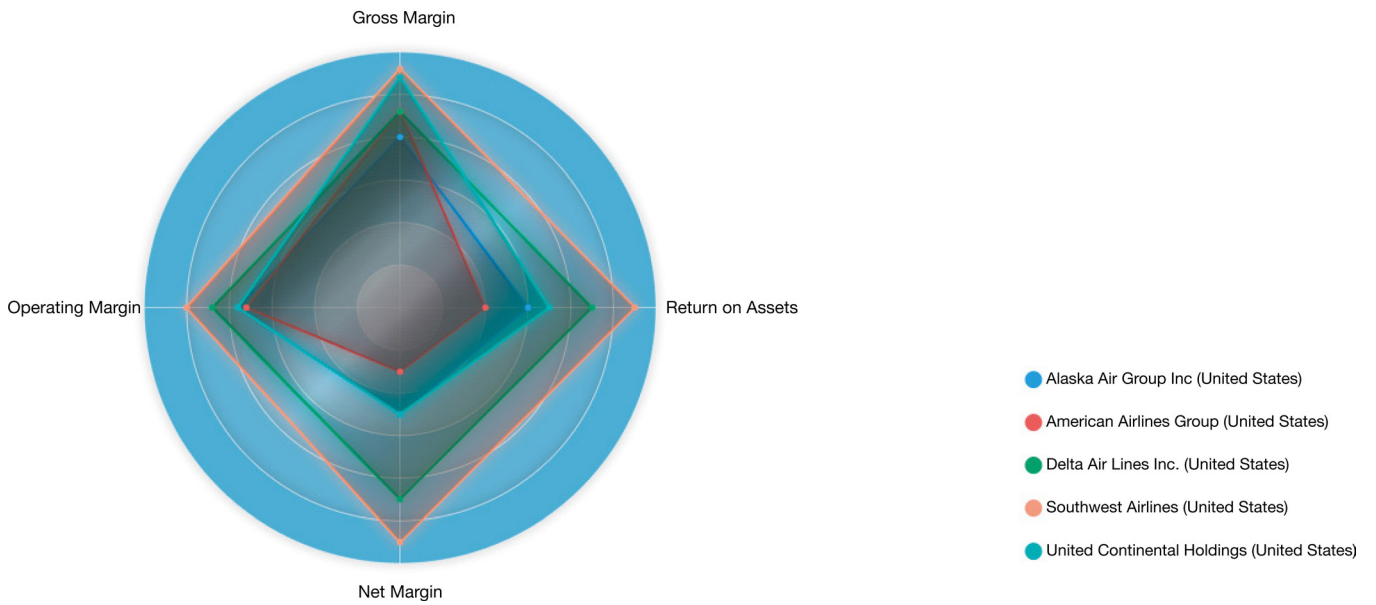## Enterprise Comparison - Profitability
(Bigger the better)

FIGURE 23   Airline profitability comparison 2021
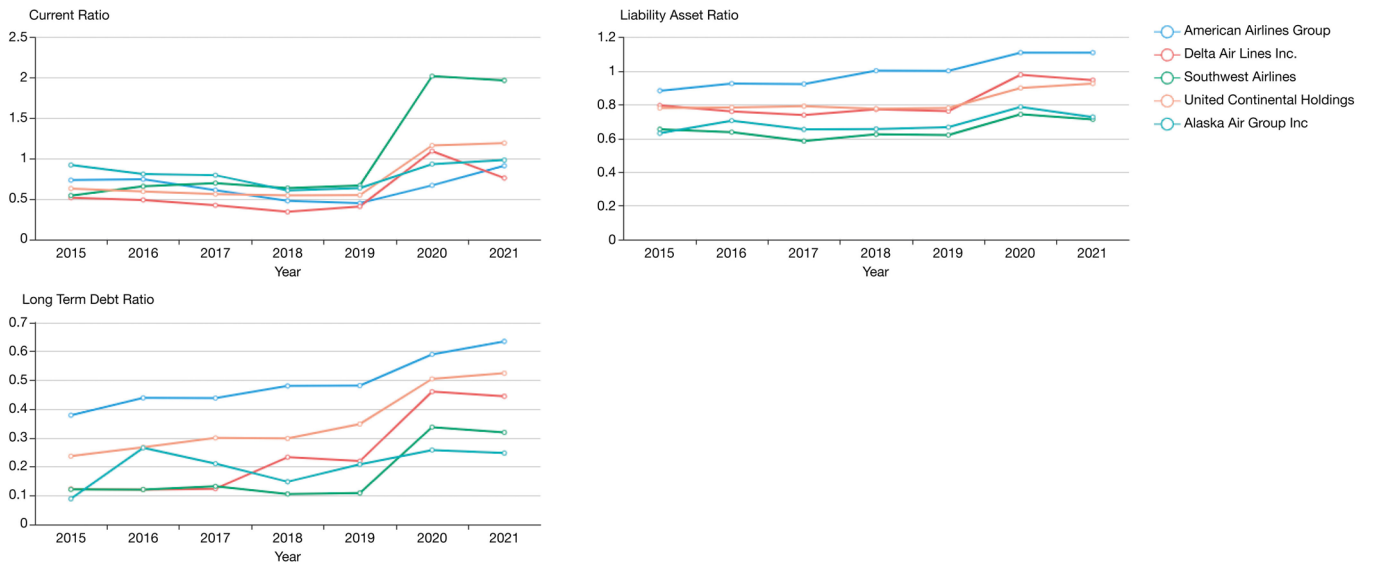Source: SCDATA[26]

FIGURE 24   Liability asset ratio and long-term debt ratio airline comparison
Source: SCDATA[27]

Actions

Correlate various KPIs to detect potential causal relationships. The driving factors may be industry, time and country dependent. Typical driving factors include pricing (gross margin), opera–tional efficiency (eg inventory turnover), liabilities (liability asset ratio), etc.

Example: Airline industry

Analysing the US airline industry 2019–21, we found a strong negative correlation between ROA and liability asset ratio, that is, a higher liability asset ratio may lead to a lower ROA (see Figure 25). Similarly, a higher liability asset ratio may lead to a lower operating margin (not shown here). Thus liability asset ratio can be an important factor that drives an airline's financial performance, that is, the more liabilities an airline carries, the more likely it will incur lower margins and ROA. For instance, AAL had the highest liabilities and the lowest ROA among all US airlines during this period.

Step 3: Breakdown analysis

Breakdown analysis breaks a company's revenue, cost and assets into various components for the objective of diagnosing the root causes for problems. For example, if the industry's average SG&A cost is 10 per cent of the revenue, but mine is 15 per cent, then I may have spent too much on SG&A. Breakdown analysis can answer the questions of how it happened by comparing the components among companies and to industry averages.[29]

Questions

• What are the key problems and their causes?

Actions

Compare individual companies' revenue and assets breakdowns to industry averages.
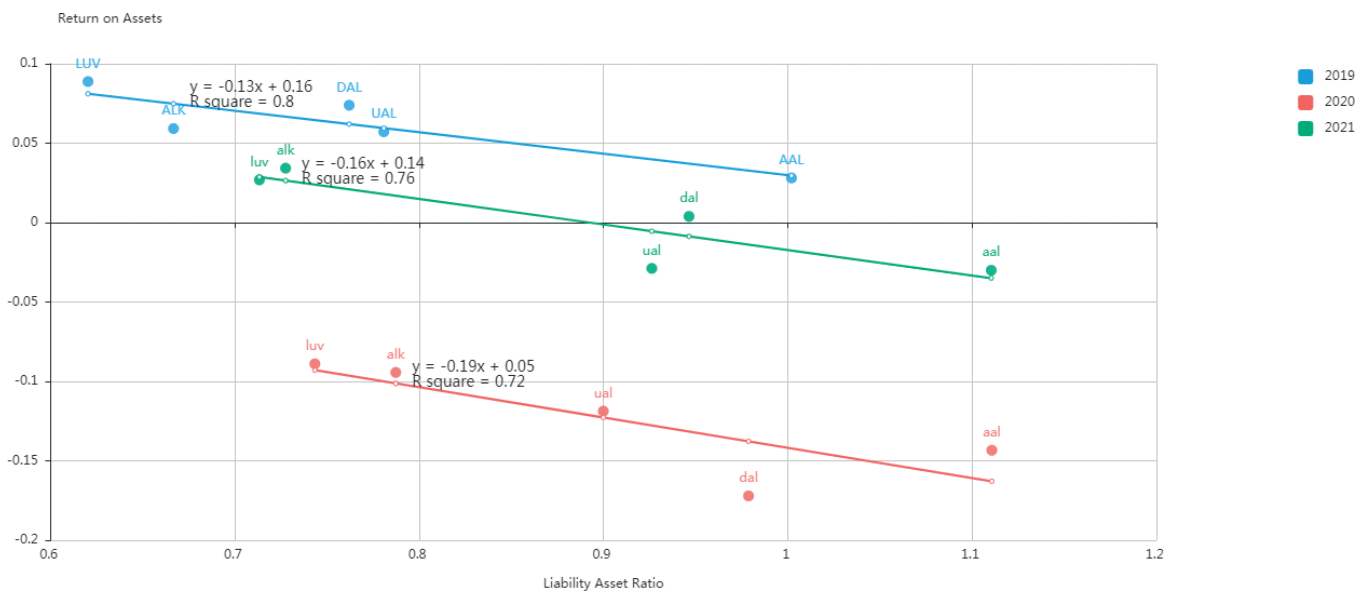

FIGURE 25 Liability asset ratio and return on assets US airlines SP500 companies (2019–21)
Source: SCDATA[28]

Example: Airline industry

Revenue breakdown

Figure 26 shows the revenue breakdown of AAL in 2019 together with the US airline industry and DAL and LUV. AAL's COGS are higher than the industry average; AAL is also higher in other costs (interest on loans for equipment, government subsidies, etc.) compared to DAL and LUV. DAL's COGS are in line with the industry average, but it is low on other costs. LUV is lower than the industry average in COGS and SG&A cost despite a high other costs. As a result, LUV and DAL have a higher net income than the industry average and AAL.

Total assets breakdown

Figure 27 shows that the breakdown of total assets of AAL, DAL and LUV and the US airlines industry, from which we can see: (1) AAL have almost zero cash, but LUV have a significant amount of cash; (2) DAL is much lighter on physical assets (ie property, plants and equipment

[PPEs]) than other airlines, explaining the reason behind its unusually small other costs. Recalling DAL generated the highest revenue in 2019 (Step 2), DAL stood out by having a better asset utilisation (ie generating a higher revenue using much lighter physical assets). LUV stood out by tightly controlling its COGS and SG&A costs.

Summarising these analyses, AAL's key problems and causes are now clear: AAL is one of the largest airlines in size but weakest in profitability, growth and financial health. Its high PPEs, proved to be more of a burden than assets, failed to generate sufficient revenue but resulted in significant cost. To be fair, the airline industry suffered a huge blow from the pandemic and almost everyone's profit margins are shrinking, but AAL is clearly the worst performer in recent years and the stock prices told the truth. Given its size and significant cash flow, AAL has the potential to turn the company and stock price around. The key to success is to improve assets utilisation, either by
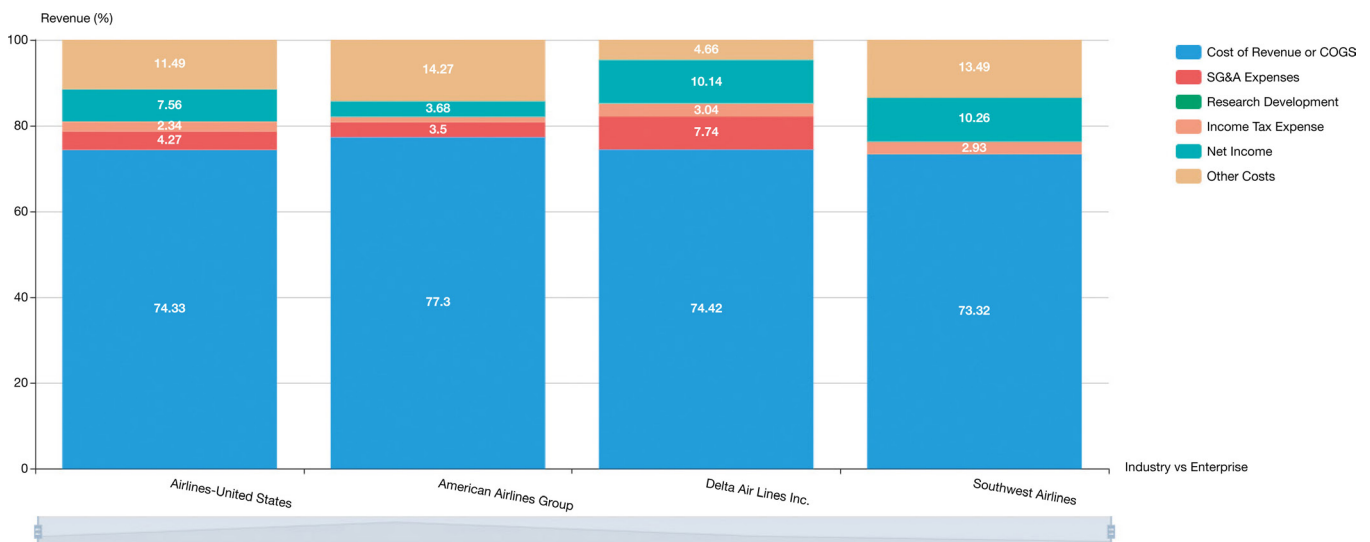

FIGURE 26 Enterprise breakdown pre-COVID-19
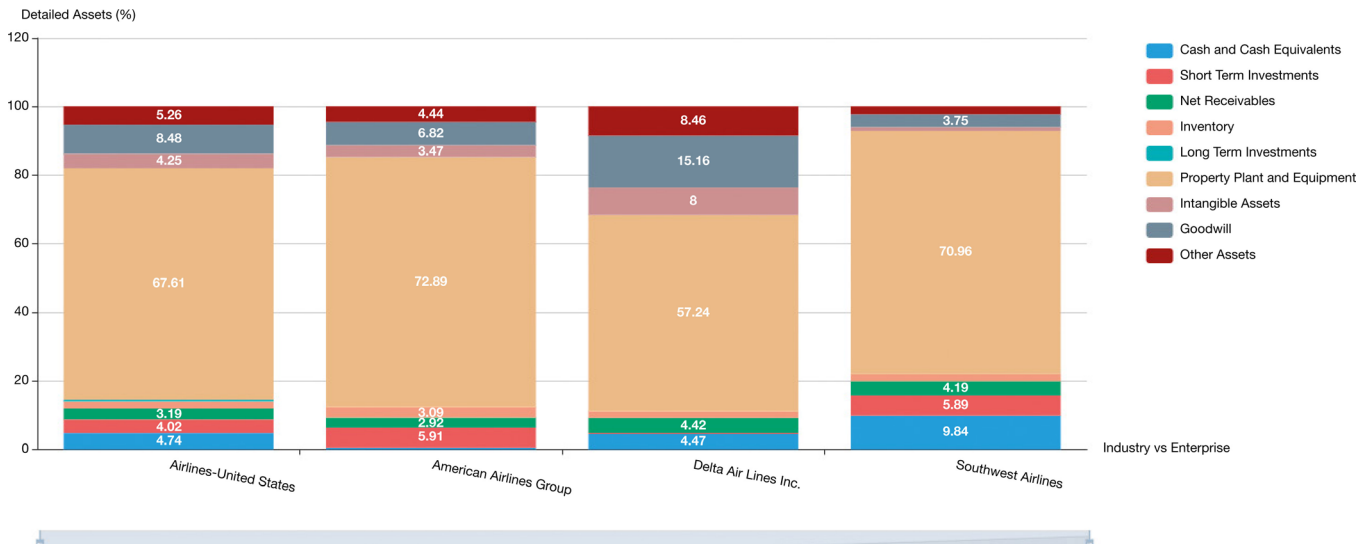Source: SCDATA[30]

FIGURE 27 Total asset breakdown for the US airline industry in 2019
Source: SCDATA[31]

better utilising its assets or potentially selling unprofitable resources. Doing so can reduce other costs and improve financial health. AAL already had sound control of its SG&A cost, but it can improve its COGS which is 3 per cent higher than the industry average in 2019.

It is commendable that AAL and the US airline industry were moving in the suggested directions by significantly downsizing PPEs since 2019 — for example, AAL reduced its PPEs from nearly 73 per cent of its assets in 2019 to 56 per cent in 2021 (see Figure 28). AAL
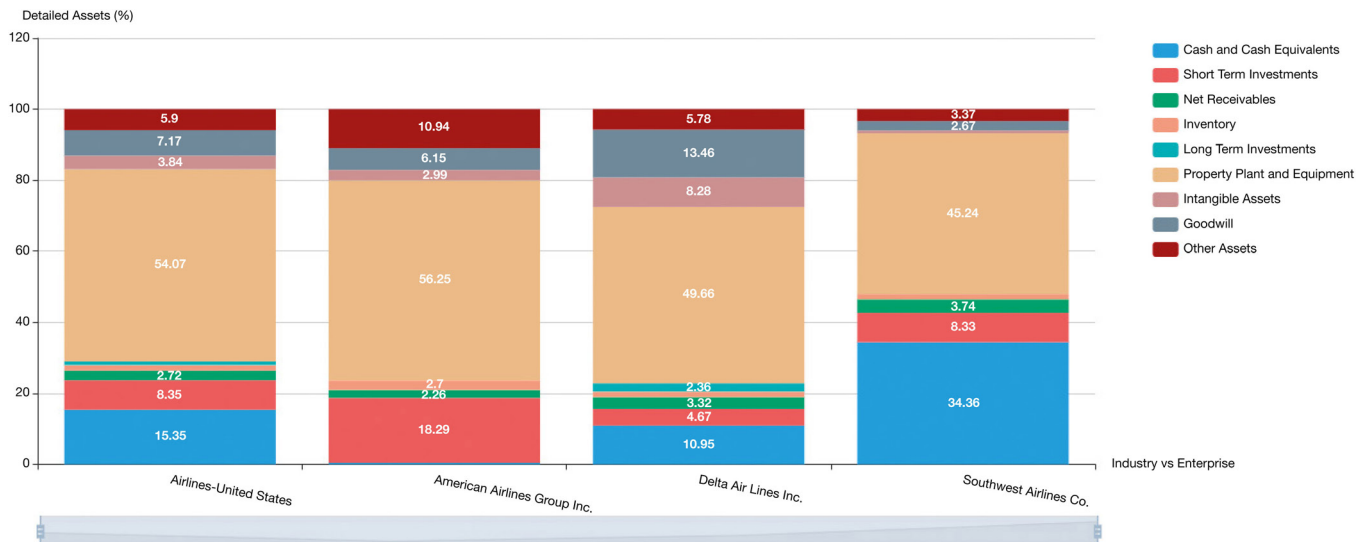

FIGURE 28 Total asset breakdown for the US airline industry in 2021
Source: SCDATA[32]

TABLE 2 Business analytics playbook for problem discovery

Phases	Steps	Questions	Actions (Analyses)
I: Industry Analysis	1.1: Industry Trend Analysis	What are the trend, market potential, and risk of the industry?	Industry Trend Analysis
	1.2: Concentration and Competition Intensity	Is this a monopolized or competitive market? Can small companies survive and thrive in this industry?	Market Share Analysis, Four-Firm Concentration Ratio
	1.3: Value Chain Analysis	What are the most valuable segment(s) along the supply chain? Should we expand up or downstream?	Supply Chain Mapping, Industry Comparison
II: Competition Positioning	2.1: Profit Frontier	Where does the company stand in the competitive landscape?	Operating Margin vs. Revenue, Return on Assets vs. Liability Asset Ratio, Operating Income vs. Total Cost or Total Assets
	2.2: Enterprise Ranking	Where is the company ranked relative to its competitors?	Enterprise Ranking
	2.3: KPI Examination	Do I have any abnormalities or potential issues undetected?	KPI Examination
III: Enterprise Diagnosis	3.1: Strengths and Weaknesses	What are my strengths and weaknesses relative to my competitors?	Enterprise Comparison, Enterprise Trend Analysis
	3.2: Value Driver Analysis	What factor(s) may drive a company's financial performance in my industry?	Value Driver Analysis
	3.3: Breakdown Analysis	What are my key problems and their causes?	Breakdown Analysis

Source: Authors

still has much work to do to catch up with its competitors, however.

CONCLUSION

This paper showcases the value and challenge of problem discovery and provides a step-by-step playbook for problem discovery and cause diagnosis through business analytics — specifically, competitive intelligence and benchmarking. We demonstrate the power of the playbook by the example of AAL in the US airlines industry. We conclude this paper by summarising the playbook in Table 2.

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(15) *Ibid*., p. 22.

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