

Visualizing Income Statements of Pharmaceutical Companies Using Sankey Diagrams

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Abstract

Financial statement analysis is foundational to evaluate business performance and the income statement provides key insights into the profitability of an enterprise. While income statement data are readily available as part of a company's annual 10-K filing, their tabular format can make it challenging to fully understand the nuances associated with company performance. To address this shortcoming, the SankeyArt platform was used to develop Sankey diagrams for 3 pharmaceutical companies that provide an alternate intuitive visual representation of company profitability. The level of income statement granularity can be modulated in the Sankey diagrams, directing focus to the areas of interest. The approach described in this study is generic and applicable across industries.

Keywords

Biotechnology, Financial Statement, Income Statement, Pharmaceuticals, Sankey Diagram

1. Introduction

Financial statement analysis is foundational to understating the performance of a company across multiple dimensions (Fridson & Alvarez, 2022). In the United States, publicly traded companies are regulated by the Securities and Exchange Commission (SEC). Additionally, the Financial Accounting Standards Board (FASB) sets financial and reporting standards, including generally accepted accounting principles (GAAP), and publicly traded companies in the US are required to follow GAAP. Under GAAP, companies are required to create a balance sheet, a cash flow statement, and an income statement which collectively

form the basis of financial statement analysis (Konchitchki & Patatoukas, 2014).

The income statement is most helpful to analyze the profit and loss associated with a business (Wahlen & Wieland, 2011). It starts with total revenues, and subtraction of direct costs associated with revenue generation helps identify the gross income and the associated gross margin. Subsequently, indirect expenses like research and development (R&D), marketing, and other costs are subtracted leading up to the operating income and the associated operating margin. Finally, interest and income tax expenses are subtracted from the operating income resulting in the net income and the associated net margin. The net income is a key indicator of profitability, and the net margin enables comparison of company performance against industry peers (Flood, 2022).

2. Literature Review

Income statements are shared both quarterly and annually and are key component of a corporation's financial statement analysis (Monahan, 2018). They contain all the information necessary to determine a company's profitability and their presentation in a tabular form is the accepted practice across the globe (Hasanaj & Kuqi, 2019). However, it has been shown that the format in which information is presented can affect the judgement of the reader of the financial statement (Liang & Zhang, 2006). For instance, investors were prone to misjudgment when information was disclosed as a footnote or in other less prominent formats (Maines & McDaniel, 2000). Providing a search option via eXtensible Business Reporting Language (XBRL) to access financial statement and footnote information increased the likelihood of users obtaining information on stock option compensation that was disclosed in the footnotes which impacted their investment decisions (Hodge, Kennedy, & Maines, 2004). A subsequent study (Nelson & Tayler, 2007) showed that data transformation by the user could impact their judgement, highlighting the importance of clarity in the presentation of financial statement data.

Furthermore, financial statement review and interpretation is not constrained to subject matter experts. Company financial statements are read by a diverse audience with varying levels of expertise (Cascino et al., 2014), and simplification of the presentation should translate to consistent understanding of company performance across all stakeholders. We believe an alternate visual representation could provide useful insights into company performance and simplify interpretation of income statements, which is the basic premise of this article.

One such visualization is the Sankey diagram, originally proposed to describe the efficiency of steam engines (Kennedy & Sankey, 1898) and since been applied across disciplines including material flows (Graedel, 2019), energy flows (Schmidt, 2008; Subramanyam et al., 2015), water resource management (Curmi et al., 2013), financial analysis (Ioannidou et al., 2018; Chong et al., 2021), visualizing microbial communities (Platzer et al., 2018), and the teaching of economics (de-Córdoba & Molinari, 2022), to name a few applications. Because Sankey

diagrams provide excellent visual interpretation of complex data, the underlying relationships that define the data are easier to understand and compare across scenarios.

3. Objective of This Study

To simplify the interpretation of income statements, we have developed Sankey diagrams for 3 pharmaceutical companies. This article includes a Materials and Methods section that lists the companies chosen for analysis along with the approach used to create Sankey diagrams for their income statements. The results section presents Sankey diagrams for the 3 companies along with an interpretation of the income statements. Finally, the conclusions section provides a holistic view of how Sankey diagrams simplify income statement analysis and their broad applicability across industries. These visual representations simplify profitability analysis enabling intuitive and rapid understanding of profit and loss. The approach presented in this study is general and applicable across industries.

4. Materials and Methods

4.1. Choice of Companies for Analysis

A total of 3 pharmaceutical companies (AbbVie, Merck and Co., and Amgen) were used in this analysis and their choice was driven primarily by the desire to include income statement diversity that would manifest in the Sankey visualizations. Abbvie did not break down 2022 revenues by categories or products and total revenues were consolidated into a single number. In contrast, Merck and Co. reported revenues across therapeutic areas and product categories resulting in more granularity compared to Abbvie and a more informative Sankey diagram. Amgen was selected because it provided the highest granularity by including revenues across each of its products. Consequently, Amgen had the highest resolution revenue breakdown resulting in the most information-rich Sankey diagram. These 3 companies represent the full spectrum of granularity expected in income statements and their associated Sankey diagrams showcase the range of income statement visualizations. For each of the 3 companies, 2022 annual income statement data were obtained from their 10-K filings (sec.gov/edgar).

4.2. Construction of Sankey Diagrams

The web based SankeyArt platform (<https://www.sankeyart.com/>) was used to construct the Sankey diagrams presented in this study. SankeyArt is intuitive and user friendly with a spreadsheet like interface to enter income statement data followed by multiple options to customize the appearance of the final Sankey diagram. As an illustration, the data entry interface for the company Merck & Co. is shown in **Figure 1**.

Data	Colors	Labels	Title	Layout
Source		Target		Amount, current
Oncology		Pharmaceutical Segment		23.095
Vaccines		Pharmaceutical Segment		10.696
Hospital Acute Care		Pharmaceutical Segment		3.385
Cardiovascular		Pharmaceutical Segment		0.579
Virology		Pharmaceutical Segment		6.317
Neuroscience		Pharmaceutical Segment		0.258
Immunology		Pharmaceutical Segment		0.913
Diabetes		Pharmaceutical Segment		4.513
Other Pharmaceutical		Pharmaceutical Segment		2.249
Livestock		Animal Health Segment		3.3
Companion Animals		Animal Health Segment		2.25

Figure 1. Data entry interface for creating Sankey diagrams for income statements using the SankeyArt platform. The corresponding Sankey diagram is shown in **Figure 3**.

5. Results

Income statements across 3 pharmaceutical companies were used to generate their corresponding Sankey diagrams. Differences in how the revenue contributions were described result in changes to the Sankey diagrams as will be shown in corresponding sections.

5.1. AbbVie

AbbVie's consolidated statement of earnings starts with total revenues of \$58.05B which form the first node in the Sankey Diagram (**Figure 2**). Subsequently, expenses across 5 categories, cost of sales (COS), selling general & administrative (SG&A), research & development (R&D), acquired IPR&D and milestones, and operating expenses, are depicted as outflows resulting in an operating income of \$18.12B, the second node in **Figure 2**. From the operating income node, foreign exchange loss, interest, and other expenses are outflows leading to the income before taxes node of \$13.48B. Finally, subtracting the income tax expense of \$1.63B leads to the net income of \$11.85B.

A simple color scheme (grey = neutral, red = expense, green = profit) makes the visualization intuitive and because the thickness of the lines is proportional to the magnitude of the value, relative contributions stand out. For instance, the

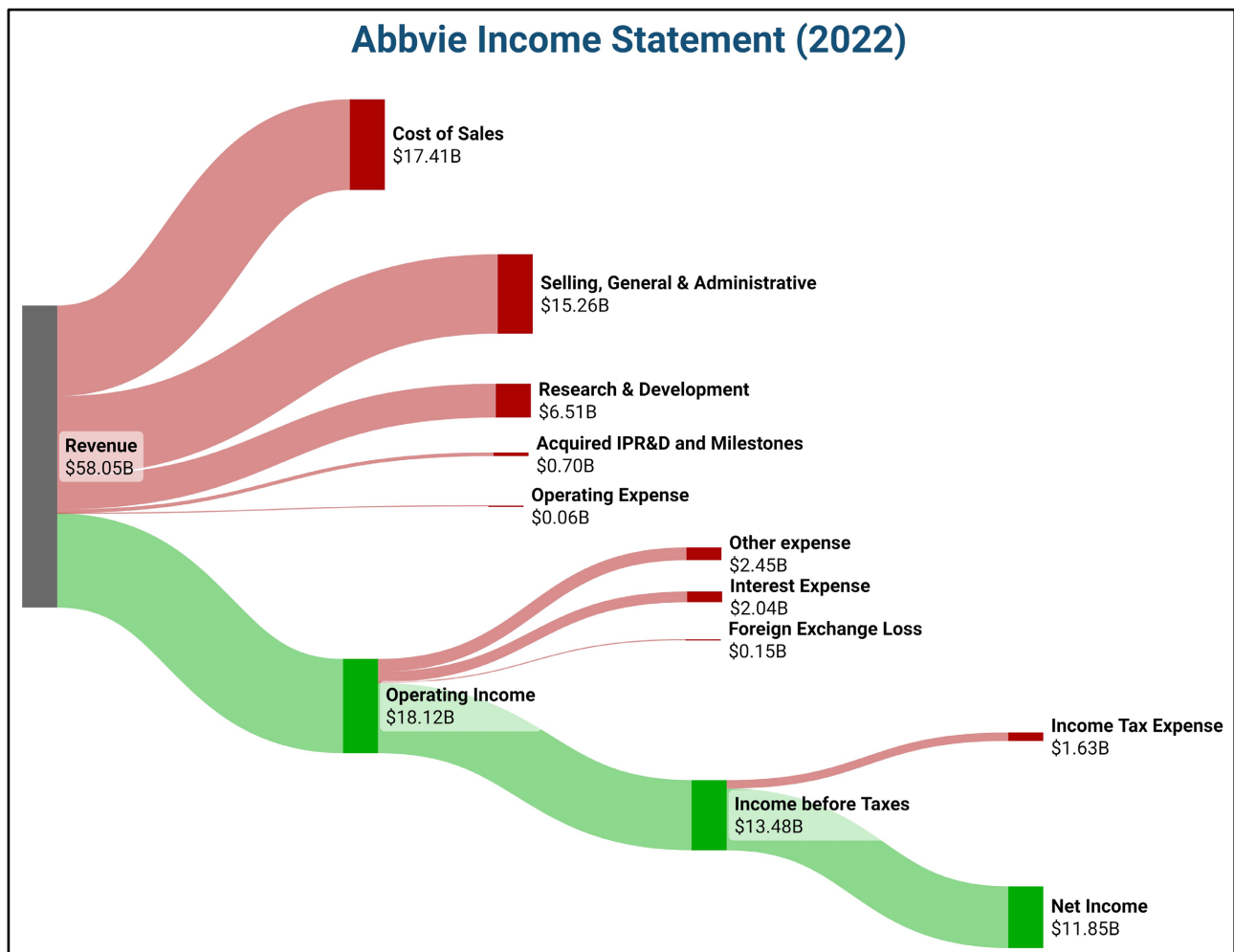


Figure 2. Sankey diagram generated using SankeyArt for AbbVie's 2022 income statement.

much higher cost of sales and selling general & administrative expenses compared to research & development investments (2.3 - 2.6X, respectively) are visually obvious from **Figure 2**. Similarly, a relatively modest outflow as income tax expense (\$1.63B) from the income before taxes node (\$13.48B) is also evident from **Figure 2**.

5.2. Merck and Co

Merck reported 2022 revenues across its pharmaceutical (\$52.01B), animal health (\$5.55B), and other (\$1.73B) segments leading up to total revenues of \$59.28B (**Figure 3**). The dominant contribution from the pharmaceutical segment is evident in **Figure 3**. Furthermore, each revenue segment was further broken down across therapeutic areas and other categories and a higher resolution view into the contributors of revenue is seen in **Figure 3**. Oncology, vaccines, and virology make up the top 3 contributors with the combined animal health segment coming in at 4th place.

Merck's R&D expense (\$13.55B) was greater than their SG&A expense (\$10.04B)

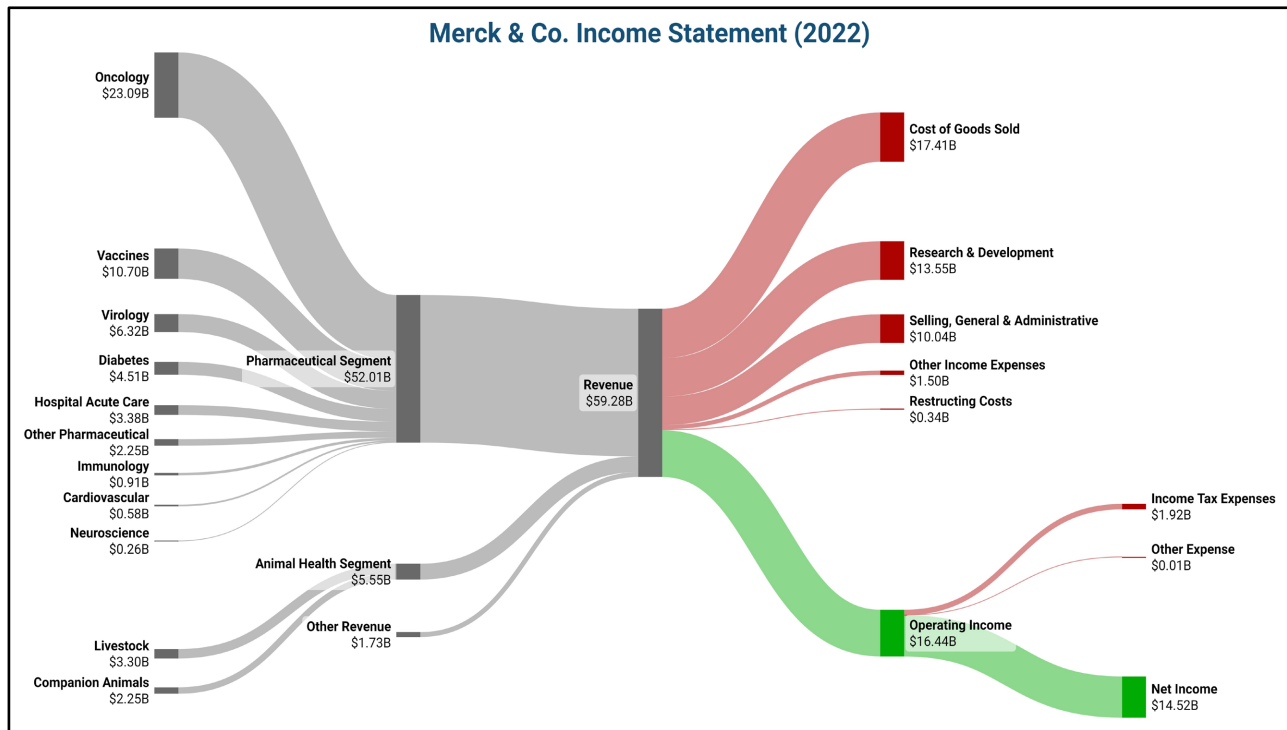


Figure 3. Sankey diagram generated using SankeyArt for Merck and Co.'s 2022 income statement.

and slightly lower than their cost of goods sold (\$17.41B). This is in stark contrast to AbbVie (Figure 2) where the SG&A and COS were > 2-fold higher than the R&D expense. Finally, income tax and other expense outflows from the operating income (\$16.44B) result in a net income of \$14.52B at a income tax rate of ~12%, similar to that for AbbVie in Figure 2.

In contrast to Figure 2 where the first node was total revenues, Figure 3 is a more granular depiction of the contributors to Merck's revenues. Their relative contributions can be easily visualized by the thickness of the connectors and arranging them in descending order also helps contextualize their overall position.

5.3. Amgen

Amgen reported revenue at the product level where 23 products were individually called out along with an Other Products category. Collectively, these resulted in \$24.8B of product-associated revenue and comprise the first node on the Amgen Sankey diagram (Figure 4). Other revenues were \$1.52B resulting in the total revenue node of \$26.32B. Figure 4 includes a gross profit node (this was not shown in Figure 2 and Figure 3) to illustrate that variations of the Sankey diagram can be generated depending upon the focus and intent of the analysis.

Accounting for R&D, SG&A, and other Opex outflows from the gross profit node leads to the operating income node. Similar to Figure 2, a pre-tax income node after accounting for interest and other expenses is included in Figure 4 which ultimately leads to net income after accounting for the income tax outflow.

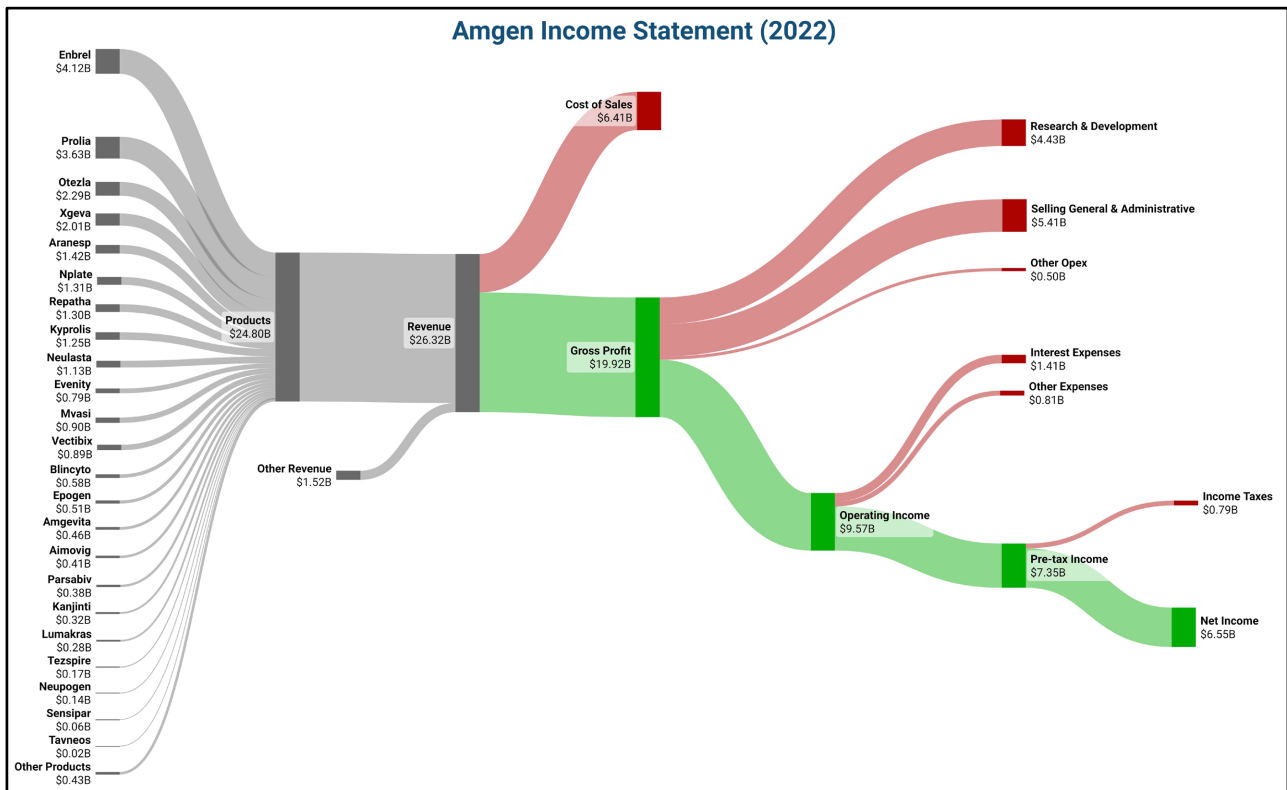


Figure 4. Sankey diagram generated using SankeyArt for Amgen’s 2022 income statement.

If required, Amgen products can be grouped by therapeutic area resulting in additional nodes prior to the products node. This would enable direct comparison of contributions across the therapeutic areas, something that is not easy to determine from Figure 4.

6. Conclusion

Using Sankey diagrams, we have developed intuitive visual representations for the income statements of AbbVie, Merck and Co., and Amgen, three pharmaceutical companies. These diagrams are intuitive and easy to follow, enabling rapid insights into company performance. Depending on the end user, these diagrams can be customized, and the granularity can be adjusted to provide specific insights for decision making.

We recommend financial analysts use Sankey diagrams in addition to conventional tabulated income statements to analyze company performance and include them in their company reports. This will simplify interpretation of company performance across a broad range of consumers, especially those without formal training in finance.

Sankey diagrams are relatively easy to construct, and their general nature makes them applicable across the spectrum of publicly traded companies across the globe. We believe they are the method of choice for intuitive and visual interpretation of income statements and need broader adoption to maximize their impact.

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Conflicts of Interest

The author declares no conflict of interest regarding the publication of this paper.

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