End-to-End Enterprise Visibility Software Packages

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Abstract

The ongoing pandemic has posed significant challenges for supply chains globally. The international lockdowns still happening have contributed to the bottlenecks seen in the flow of raw materials and finished goods and the disruptions seen in manufacturing. In short, the pandemic has brought to light many overlooked vulnerabilities in the global supply chain. The most critical of these problems lies in analytics. Many major companies currently process supply chain data in the form of excel spreadsheets which has been shown to be highly problematic and holistically inefficient. This paper will examine digitalized supply chain software/dashboards and explore how major conglomerates can leverage these descriptive-analytic technologies to engage in collaborative planning with suppliers and customers and to obtain end-to-end enterprise visibility.

Keywords
Supply Chain, Logistics, End-to-End Enterprise Visibility, and COVID-19

1. Introduction
COVID-19 has ravaged the world. Initially thought to be benign, the virus shut down the global economy and brought worldwide operations to a screeching halt. People have lost loved ones, their jobs, and their livelihoods. Once reaping the rewards of a stable and healthy global economy, multinational conglomerates now watch as their revenues shrink to a mere fraction of what they once were. However, our recovery from the pandemic has been nothing short of magnificent. With the slow reopening of businesses and the resuming of global operations, we have been able to make up significant ground and almost carry on with business as if the pandemic never happened.

In truth, we cannot put the pandemic behind us as it's shown us many vulnerabilities in the global supply chain, especially with how we currently manage data and conduct analysis. It's been found that many of these major organizations process supply chain data in the form of excel spreadsheets which has been shown to be highly problematic due to dataset size and lack of visualization, thus incurring high amounts of downtime. Without effective logistic strategies, data visualization, and adaptable infrastructure to combat the rising strains on our supply chains, we will soon be unable to coordinate the movement of our products timely, safely, and effectively.

1.1 Objectives
This paper aims to analyze the impact that descriptive-analytic technologies could have on our supply chains and manufacturing processes when paired with End-to-End Supply Chain methodologies. This paper will provide insight into how implementing modernized supply chain-centered technologies could make Supply Chain Management more methodical, streamlined, and productive.

1.2 Paper Organization
This paper is organized into various key sections. These sections include an explanation of Descriptive-Analytic Technology, an overview of what End-to-End Enterprise Visibility is, a collection of Case Studies on the matter, and a conclusion to wrap up your future understanding of End-to-End Enterprise Visibility software packages.

1.3 Methods
Extensive research into descriptive-analytic technologies, end-to-end Enterprise visibility, and their impacts has been made to present a clear picture of the current state. Several examples of Enterprise visibility software packages and their implementations will be discussed, highlighting the positives and negatives in multiple industries. Using the literature review and case studies, we are able to deduce the best practices for implementing descriptive-analytic technologies and end-to-end Enterprise visibility software packages.

2. What Are Descriptive Analytics and How Are They Used
Descriptive analytics are commonly used and often called the most fundamental form of analytics that companies use. Descriptive analytics can be used in every aspect of a business and help keep track of trends and operational performance (Morris, 2021). An example of descriptive analytics would be key performance indicators (KPIs). These provide information like year-on-year percentage sales growth, revenue per customer, and the average time customers take to pay bills.

While it is easy for companies to accumulate tremendous amounts of data, it will be unusable unless some analysis is performed. Knowing that thousands of customers place orders every year is not very helpful, but taking it a step further and figuring out how much, on average, customers were spending begins to reveal useful information. Descriptive analytics is the first step in transforming raw data into useful information (Morris, 2021). Companies use this information to self-evaluate and see if operations are, in fact, running accordingly. Examples of metrics that are produced by descriptive analytics are reports, visualizations, and dashboards.

Descriptive analytics assist individuals in making well-informed decisions that will help direct the business in the right direction. Uncovering patterns/trends that were lost in the raw data, allowing higher management to recognize issues easily, and having the capability to share information across departments and with people outside of the company are key takeaways from descriptive analytics.

2.1 What is Descriptive-Analytic Technology
In short, Descriptive Analytic technologies are software packages and dashboards that aggregate existing sources of data and apply statistics and modeling to understand an institution's past and current data. These technologies then enable a user to display this data in various forms, such as graphs, charts, and reports, which paint a picture depicting the current state of affairs within a business. The use of Descriptive-Analytic Technology is slowly becoming a standard practice for many major supply chain participants, from manufacturers to retailers, as these data-visualization software packages have made it easier to do several things, including forecast demand and set prices for goods.

2.2 Importance of Descriptive-Analytic Technologies
Descriptive Analytic technologies essentially transform historical and "now" data into easily accessible, visually digestible, and efficacious tools. These technologies and the informative tools they produce can equip teams of Engineers across an organization with the insight they need to make sagacious decisions, whether in day-to-day operations or for future operations in the pipeline. Moreover, these Analytic technologies can arm Supply Chain Managers with the facts needed to quickly make sound, data-driven decisions resulting in calculated, successful business strategies. Simply by leveraging available data to provide current and future insights, accurate information can be directed to the right team at the optimal time. This would result in less downtime, saving time and money across all touchpoints of an organization's supply chain.

2.3 Examples of Descriptive-Analytic Technology
Supply chain analytics and operations would solely depend on personnel's attentiveness and skills without the use of Descriptive Analytic technologies. By sifting through the data and actively seeking patterns with data algorithms and machine learning, this technology automates the process of understanding what's happened, what's happening, and what will happen and could even be used to ask what's wrong and where.

A prime example of Descriptive Analytic technologies being used in this manner could be seen in Amazon's use of barcodes at their fulfillment and distribution centers. These barcodes, which could be found all over a package, are scanned for tracking purposes and feed data into Amazon's very own Descriptive Analytic software. Hypothetically

speaking, if something were to happen and a sharp increase of "no-reads" in a particular station was recorded, an online PCS - descriptive analytics software could inform a site manager to check on the station to ameliorate the issue. Additionally, advances in Amazon's Descriptive Analytic software have enabled the software to leverage current data inputs to aid in the troubleshooting and identification of possible causes for the increase in "no-reads," thus reducing downtime further.

In General, Descriptive Analytic technologies use historical data to better grasp:
- Current or historic supplier lead times
- Sales and operations data

Descriptive Analytic technologies could also be used for:
- Creating plans and forecasting
- Simulating performance
- Analyzing risk management

3. What is End-to-End Enterprise Visibility

End-to-End Enterprise Visibility, also known as End-to-End Supply-Chain Visibility, enables transparency at all touchpoints of Supply Chain Management, from the procurement of raw materials to the delivery of a finished product to a customer. This transparency is only possible through thorough observation of each step in the process, recording related data, and organizing this data in an accessible data management space. This data can then be reviewed, analyzed, and leveraged with Descriptive Analytic technologies to provide real-time, keen insights that drastically improve business processes, financial planning, and overall strategic decision-making.

End to End Enterprise visibility enables one to oversee the following all at once:

1. Procurement and inventory management
2. Finance
3. Logistics
4. Operations
5. Quality control
6. Sales and customer service

3.1 Importance of End-to-End Enterprise Visibility

Given the complexities of global supply chains and the tedious management they require, it's necessary that organizations have some sort of visibility across their supply chains. The pandemic dramatically demonstrated the importance of this visibility. Many multinational conglomerates and Fortune 500 companies without full and real-time Supply Chain visibility lacked the resilience to push through and continue business at previous volumes. Companies with visibility going into COVID-19 could hedge against the risks the pandemic threw at them, better manage their supply chains, and ultimately recover with far greater resilience and agility.

Supply Chain visibility improves supply chain performance in 4 key ways:

- Full monitoring: Being able to oversee and monitor all processes, organizations can yield a complete trove of data for analysis, financial reporting, and evaluating supply chain operations using metrics like KPIs.
- Communication and Collaboration: End-to-End visibility allows for clearer communication which enables teams to take more of a collaborative approach to solving interdisciplinary problems. Down the line, this will result in stronger partnerships between institutions, key suppliers, and their service providers and stands to support the development of shared initiatives for growth and innovation for all.
- Improved Agility and Responsiveness: End-to-End Visibility accounts for and has data-driven contingency plans in store for major supply chain disruptions. This ensures that all looming calamities are expected and mitigated in a fashion that allows the organization to rebound as quickly as possible.
- Inventory Management: Holistic visibility allows businesses better to match their demand forecasting to their inventory strategies. This enables companies to employ more adaptable and accurate safety stock management approaches while bettering their turnover rate optimization.

3.2 Industries affected by a lack of End-to-End Enterprise Visibility

3.2.1 Food Industry

COVID-19 has affected every industry in one way or another, but the food industry might have been the hardest hit. There have been restrictions on indoor seating, sanitation, and social distancing requirements. In addition to this, the pandemic has forced bottlenecks of essential products forcing inventory shortages. This has forced small businesses to struggle and raise prices. As of May 2021, prices in the food industry have risen 10.1 percent. There has not been an increase this high since 1981. and there is no choice but to adapt. Produce is extremely tricky because, unlike most other products, it has an expiration date. If you order too much, products will expire, and you will waste money on inventory. On the other side, if you do not order enough, you will be unable to fulfill customer requirements leading to missed sales. Additionally, customer demand for international foods forces a long journey of raw materials across the supply chain. The solution is end-to-end visibility. Knowing where your raw materials are at all times is not preferred but necessary for small businesses that provide fresh food to survive without continuing to skyrocket prices.

3.2.2 Automotive Industry

An additional industry that could benefit greatly from end-to-end visibility is the automotive industry. Of all industries, automotive struggles the most with this issue, with roughly 83% of automotive businesses listing transparency as the number one issue. The reason for this is that the finished product for this industry requires the coordination of several different suppliers and manufacturers that each abides by their own supply chain. This requires each sub-tier of this chain to have immediate access to tracking and information. It is estimated that pre-delivery failures cost car companies around $40 billion in insurance claims yearly. End-to-end visibility would help with this tremendously. Implementing a system using RFID tracking of HD barcodes would allow visibility across a complex supply chain that desperately needs a way to know where and when each part is at all times.

3.2.3 Pharmaceutical Industry

Perhaps the most important industry that matters the most is the pharmaceutical industry. In this industry, it is not a matter of losing or gaining money; it is a matter of life and death. According to the World Health Organization, there are roughly around 1 million deaths per year due to counterfeit drugs. The losses for pharmaceutical companies are an estimated $200 billion. One of the positives of COVID-19 is that it has sped up the process of implementing an end-to-end visibility process due to the threat of fake vaccines. Implementing a system in this industry would allow companies to see the movement of the drugs across the supply chain, prevent counterfeit drugs from entering the market, and potentially monitor the integrity of the drugs. Remember that drugs must be kept at a certain pressure and temperature to retain the chemical makeup of their intended use. The solution is to implement a system that can monitor these conditions at all times. While this may be a challenging feat to accomplish, it could save lives which is of the utmost importance.

4. Case Studies

4.1 Case Study: FourKites

To further understand the importance of end-to-end enterprise visibility software, we looked at PetSmart, a privately held American chain of pet superstores that sell pet products, services, and small pets. The case study (FourKites, 2021) done on PetSmart describes how PetSmart was looking for a way to minimize late and early deliveries and reduce labor costs. Being the leading North American pet company, they needed to accomplish this goal across more than 1,650 stores throughout the U.S. and Canada. PetSmart has more than 180,000 shipments each year. Their late deliveries and other supply chain disruptions created a lack of flow between store associates, carriers, and company headquarters and put unnecessary pressure on storefront workers.

To combat this challenge, PetSmart selected FourKites to provide freight visibility as a solution for its supply chain issues. By introducing greater end-to-end visibility, PetSmart was able to identify the cause of disruptions to store operations and minimize their impact on staff productivity. By increasing staff productivity, PetSmart was also able to dedicate more hours to tasks like improving the customer experience with pet parents rather than waiting at the loading dock.

Kim Palombo, the Vice President of Transportation & Compliance at PetSmart, said, "Our goal is to deliver the best possible customer service, and supply chain visibility plays an important role in helping us get there." When PetSmart implemented this software that provided them with supply chain visibility, they saw major improvements in tracking consistency, accurate truck ETAs, and a decreased need for unreliable call centers for communication. With this visibility and access to their own data, PetSmart was able to take a frustrating liability and transform it into a powerful asset to build a competitive advantage.

4.2 Case Study: Roambee

Telkomsel is the largest mobile telecommunication company in Indonesia that is leading the way in transforming the industry. They provide many digital innovations for the government's "Making Indonesia 4.0" initiative. To continue down this path of innovation and success, **Telkomsel** decided to partner with Roambee. Roambee offers supply chain visibility on demand for on-time, in-full, in-condition delivery of shipments and assets anywhere in the world (Roambee, 2022). This software will also provide information like real-time location and condition of goods, including temperature, humidity, and air pressure.

In hopes of accelerating Indonesia into the "Industrial Revolution 4.0", **Telkomsel** integrated IoT technology to improve their business overall. The CEO of **Telkomsel,** Setyanto Hantoro, said, "... this new solution is created to increase operational efficiency, optimize productivity, and when implemented nationally, to expand Indonesia's competitiveness" (Telkomsel, 2020).

An example of how IoT technology has replaced obsolete practices at **Telkomsel** is in their monitoring system. The original system required manual data entry, which was slow, complicated, and prone to human error. The new solution that was implemented is an automated system that monitors as well as provides real-time information about the assets' condition. This will overall reduce operational costs and human error and ensure product quality. While this solution worked for **Telkomsel**, it is important to realize that it can also be implemented across industries like food and beverages, fast-moving consumer goods (FMCG), pharmaceuticals, logistics, and manufacturing. Cold chain monitoring, inventory management, and shipment monitoring are some of its use cases. **Telkomsel's** partnership with Roambee is a great example that shows how end-to-end IoT-based solutions are valuable and effective in today's supply chain.

4.3 Case Study: Parkour SC

With pharmaceutical companies losing billions of dollars to spoiled products, we looked at **CSafe Global** and the case study done by Parkour SC, formally known as Cloudleaf, to further see the benefits of implementing end-to-end visibility. **CSafe Global** is a cold chain shipping company that provides life-enhancing pharmaceuticals to patients worldwide. In the cold chain shipping industry, it is vital that shipments arrive on time and that the packaging is well insulated to prevent the product from spoiling. However, in real-world practice, delays will occur due to traffic, and packaging can be damaged throughout any stage of the supply chain. In some cases, if the spoiled pharmaceuticals are delivered and accepted, it could lead to "these drugs not only [being] ineffective, but harmful and possibly even life-threatening to the people who count on them" (Veerina, 2022).

In knowing all this, **CSafe Global** looked toward Cloudleaf to provide them with total visibility throughout the supply chain. To ensure that all factors were accounted for, Cloudleaf worked with **CSafe Globa**l to incorporate a custom digital visibility software to provide not just information about the truck or container the product is on but as well as factors around the temperature, condition, and timing of both the package and the location. This allowed for **CSafe Global** to have 24/7 access to monitor every shipment and intervene if necessary.

Parkour SC also provided end-to-end visibility software to another global pharmaceutical company that dealt with the transportation of plasma. This company "lost tens of millions of dollars yearly due to plasma sample spoilage, re-testing labor costs, and FDA compliance issues." The global pharmaceutical company was having a similar issue with the visibility of products during loading/unloading and a lack of insight into the surrounding environment's temperature. The company relied on handheld RFID bar code scanners, which did not provide them with enough visibility of where the product was to interfere with the shipping facilities, resulting in them losing $5 million for each spoilage of plasma. After Cloudleaf implemented its solution, which included a software platform paired with 5,000 sensors and 60 gateways, the global pharmaceutical company could accurately monitor the plasma samples' location, dwell times, condition, and movement history (Cloudleaf 2020). This solution worked so well that the company had

100% visibility with 100% accuracy resulting in 50 times their ROI. In the CloudLeaf article, Maria Nieradka was quoted stating, "Technologies such as the Cloudleaf platform, that enable you to get real-time, granular data providing complete visibility into your supply chain, along with smart contingency planning, are now required to deal with managing day-to-day business, achieving business strategy and being able to manage the next risk that comes your way" (Veerina 2022).

5. Conclusion

Today, Supply Chain managers square up against growing challenges encircling the increasing complexity, rising volatility, multi-layered cost structure, and risks attributed to their organization's Supply Chain. Managers at major conglomerates find themselves asking where their goods are, are their goods on time, how much they have in inventory, and how much safety stock they have. End-to-End Enterprise Visibility allows these Supply Chain Managers to answer these questions and more in a tenth of the time. Visibility gives these managers unparalleled access to data across an organization and allows them to ensure they have complete and accurate information truly. This enables SCMs to communicate and collaborate effectively to beat stakeholder and customer expectations, engineer better product offerings, and optimize business processes to build value and support institutional goals.

SCMs can then review and leverage the data End-to-End Visibility provides with Descriptive Analytic technologies. Descriptive Analytic technologies are tools that aggregate data and apply statistics and modeling to create reports depicting an institution's past and current data. That said, the greater an organization's visibility, the more accurate and complete data a Descriptive Analytic software can utilize to create more strategically useful insights. These improvements and scalebacks can be applied anywhere within an organization to improve everything from cash flow management to NPI and the development of future products. Furthermore, more recent advances in Descriptive-Analytic Technology have enabled Supply Chain Managers with the opportunity to apply multiplex mathematical models and Machine Learning to copious amounts of historical data to perform predictive analytics. This aids Supply Chain Managers in predicting near-future events, thus providing them with further insight into possible next steps their organization could take to ensure future success.

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Biographies

Kiyavash Azim is a fourth-year Manufacturing Engineering student at Cal Poly San Luis Obispo. He has worked as a Supply-Chain systems developer for startups in the San Luis Obispo Area over the past 2 years, the most recent one being Harvestly.co. He is currently working as a Global Operations Automation-Manufacturing Engineering Intern for NAND flash memory manufacturer Solidigm Technologies. He also serves as the CTO and Co-founder of an NFT merchandise and Web 3.0 marketplace known as Badabing. During the school year, he plans on continuing his work at Solidigm and scaling his business all while completing his degree. After graduation, Kiyavash looks forward to contributing further to the Manufacturing space and aiding in finding solutions to the world's complex problems.

Zack Wagoner is a fourth-year Manufacturing Engineering student at Cal Poly San Luis Obispo. Previously, he worked at Brymax Construction Services, a mechanical construction company that designs large-scale HVAC systems for buildings such as airports, schools, and casinos. During the school year, he plans on performing a work shadow for a prosthetics clinic in the vicinity of his university. Next summer, he plans on working an internship in the manufacturing field. He hopes that three different engineering disciplines will help him decide on his career path. He is interested in problem-solving, people, and seeing a process from start to finish. After his fourth year, he will be pursuing a graduate degree in Engineering Management at Cal Poly. Upon graduation, he plans to work in an engineering discipline that he is most passionate about.

Samantha Giangreco is a third-year Manufacturing Engineering student at Cal Poly San Luis Obispo. She has spent her last two summers working at Nanophorm LLC, which is a small-scale prototyping machine shop that specializes in optics and diamond turning. During the school year, she plans to be a teaching assistant in the Manufacturing Engineering labs as well as be an active officer of the Society of Women Engineers. Samantha also plans on pursuing the blended 4+1 program that Cal Poly San Luis Obispo offers to get her graduate degree in Engineering Management. While being ahead on her curriculum, she plans to work part-time in the Manufacturing Engineering field during her fourth and fifth years to narrow down her interests. After graduation, she anticipates getting a job in the Manufacturing Engineering field and looks forward to what the future holds!

William Marquez is a fifth-year Manufacturing Engineering student at Cal Poly San Luis Obispo. He has previously worked at Duffy Boating Company, working on SolidWorks models for boat fixtures and components. Throughout the school year, he plans on obtaining an internship or co-op in Manufacturing to further advance his experience and prepare for graduation. Post-graduation, he plans on pursuing a job in the field of Manufacturing Engineering and potential return for a graduate degree in Manufacturing.

Mohamed Awwad is an Assistant Professor in the Department of Industrial and Manufacturing Engineering at California Polytechnic State University (Cal Poly), San Luis Obispo, CA. He received his Ph.D. and M.S. degrees in Industrial Engineering from the University of Central Florida, Orlando, FL, USA. Additionally, he holds M.S. and B.S. degrees in Mechanical Engineering from Cairo University, Egypt. Before joining Cal Poly, San Luis Obispo, Dr. Awwad held several teaching and research positions at the State University of New York at Buffalo (SUNY Buffalo), the University of Missouri, Florida Polytechnic University, and the University of Central Florida. His research and teaching interests include applied operations research, logistics & supply chain, blockchain technology, distribution center design, unconventional logistics systems design, and OR applications in healthcare and the military.