Chapter 5
Aligning Data Analytics and Supply Chain Strategy in the Biopharmaceutical Industry

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Abstract Much has been written recently about the important role that data and analytics will play in improving productivity and profitability of companies in the biopharmaceutical industry. Data analytics will be a source for value creation and sustained competitive advantage for companies as new technologies like the Internet of Things and digitization of supply chain play a role in transitioning this industry into a more customer-centric model. This paper provides an overview of the status of the pharmaceutical industry and role that data analytics plays in supply chain management. The objective of this paper is to provide a use case example of implementation of a supply chain blueprint model including specifics of technology platforms, planning and optimization tools, and value stream mapping that have enabled tremendous cost savings at AstraZeneca. Lessons learned from experience with consulting to other companies in the biopharmaceutical space in the area of data analytics and strategy are outlined. The importance of fostering a two-way dialogue between members of the business community and educators and introducing new programs like the future leaders program and Supply Chain Boards in bridging the gap between theory and practice through meaningful partnerships is also discussed.

Keywords Pharmaceutical industry · Supply chain management · Data analytics · Technology platforms · Planning and optimization tools · Value stream mapping

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Introduction

Big data is unique because of the volume generated, variety of data types (including texts, pictures, videos), and the high velocity of data processing, which today is both widely available and much less expensive to access and store (McAfee & Brynjolfsson, 2012). Big data is more than a buzzword; it is a competitive resource with significant implications to company strategy and alignment with the stakeholder-based view of the firm. Big data are being used to transform industries with better decision-making capabilities that allow for improved profitability (Mayer-Schönberger & Cukier, 2013). Based on their large-scale study, McAfee and Brynjolfsson (2012) note that companies which characterized themselves as data-driven were more productive and more profitable than their competitors. In the pharmaceutical industry, applications of big data are transforming all aspects from drug discovery to development to marketing (Copping & Li, 2016).

Big data have the potential to revolutionize supply chain dynamics. To make the most of the big data revolution, supply chain leaders need to understand and embrace data science and implications for supply chain decision-making (Waller & Fawcett, 2013). Specifically from a supply chain strategy perspective, data science can be applied in qualitative and quantitative ways to solve problems in supply chain as well as be used as a predictive tool in strategically improving company performance and providing sustained competitive advantage. The objective of this paper is to seek to understand how best to align supply chain strategy and data analytics for value creation in the biopharmaceutical industry. A review of the present status of the industry and the important role that data analytics is expected to play in supply chain strategy is outlined. The experience with consulting to companies in the pharmaceutical industry and lessons learned in linking data analytics to supply chain strategy is reviewed. The evolution and development of the supply chain blueprint and importance of data analytics are detailed in a case study of AstraZeneca, a global biopharmaceutical company. The role that people, process, and technology play to enable operational cost savings in supply chain at AstraZeneca is reviewed. We also look at how best to bridge the gap between theory and practice as we look at emerging trends in linking supply chain strategy to data analytics.

Background

AstraZeneca is a global, science-led biopharmaceutical company operating in a variety of therapeutic areas (oncology, respiratory, neuroscience, cardiovascular, etc.) and developing medicines that are used by millions of patients worldwide (AstraZeneca, 2017).

Biopharmaceutical companies produce medicines that have biological basis. Thus biopharmaceutical companies use living organisms like bacteria, yeast, etc. to manufacture medicines as opposed to chemical synthesis that pharmaceutical companies use.

Biopharmaceutical companies are a rapidly growing subset of the pharmaceutical industry and make up about 20% of the pharmaceutical market (Otto, Santagostino, & Schrader, 2014). The $967 billion global pharmaceutical industry (Statista, 2017) has been experiencing an increase in the volume, variety, and velocity of information as every aspect of the value chain in this industry has undergone examination for cost and efficiency even as patient expectations are changing. This industry which has been struggling with growth and operational efficiency is transitioning to a more consumer-centric industry. In the USA, pharmaceutical companies, insurance companies, and hospitals are in the midst of consolidation to enable value (rather than volume)-based outcomes that call for lowering prices, streamlining for operational efficiency and convenience. This industry is increasingly recognizing the importance of linking data and analytics to business strategy for value creation (Mentesana, Rotz, Strang, & Swanick, 2017).

The emergence of business analytics as a critical business tool for value creation and competitive advantage is due to the widespread use of digital technologies (Chen, Chiang, & Storey, 2012). Digital is transforming the world of business, and the pharmaceutical industry is no exception. While big data deals with the ability to process data that has velocity, variety, and volume, business analytics refers to using mathematical, statistical, and optimization techniques for deriving insight (Accenture, 2014) to enable organizations make better business decisions (Muhtaroglu, Demir, Obali, & Girgin, 2013).

Supply chain for the pharmaceutical industry involves all value-added activities needed to manufacture the product to be delivered to the marketplace (whether to the hospital, pharmacy, or patient). Traditionally the supply chain of pharmaceutical companies has been complex and not very cost-effective. In the era of blockbuster drugs, the supply chain problems were not as serious, but in today's competitive environment with patent expirations denting revenues and move toward outcome-based thresholds, this area needs a serious relook. There are numerous forces reshaping the pharmaceutical environment: diversity in products and processing technologies, shorter product lifecycles, ability to scale up and down rapidly, growing importance of emerging markets, environmental regulations, greater need for risk management, etc. which calls for radically changing supply chain operations (PWC, 2017).

While traditional supply chain planning systems have focused on day-to-day operations and have limited analytical (modeling and forecasting) capabilities, advanced analytical systems using mathematical, statistical, optimization, and visualization tools have predictive capabilities thereby allowing for real-time insights and a proactive response to optimize supply chain decisions (SAS 2010). The pharmaceutical industry is aggressively looking to implement new technologies and concepts like Internet of Things (IoT), digital supply chain, and Supply Chain 4.0, particularly in logistics and supply chain management (Wamba, Akter, Edwards, Chopin, & Gnanzou, 2015), to improve operational efficiencies while meeting patient needs better. The value of analytics in logistics and supply chain operations is to improve the visibility, flexibility, and integration of global supply chains in terms of sourcing and logistics (Genpact, 2014), inventory management, handling cost fluctuations, and demand planning (Wang, Gunasekaran, Ngai, & Papadopoulos, 2016).

Aligning Business Strategy and Analytics

There are three key advancements in the use of big data that have helped industries capture value using data and analytics:

- The invention, proliferating adoption, and ease of use of the Internet
- Continued rapid cost reduction of computing processing and storage products
- Exponential technologies and computing power improvements

These advancements have led to an explosion in data generation and in a lot of cases an analytics gap as relates to strategy. The issues related to aligning strategy and analytics depend not only on business process and integration but also on where each business is along the spectrum in the adoption and application of information technology in the big data world today.

Lessons Learned from Consulting in the Pharmaceutical Industry

Some examples of lessons learned (Lee, 2016) from consulting to companies in the pharmaceutical industry on linking analytics and strategy are outlined below:

1. Importance of developing realistic trends – This was proved for a global pharmaceutical company's subsidiary operating in a developing country where regulatory and government policy changes derailed the old methodology affecting budgets and projections. Analytics helped quickly reset issues in the supply chain area by developing realistic projections in the new (changed) environment.
2. Improving forecast accuracies in the supply chain – Analytics was used to improve forecasting accuracies by 30–50% in a US-based pharmaceutical company's supply chain. Previous forecasts were hampered by a lack of focus and scope in aligning business strategy and analytics because individual departments viewed certain key metrics as irrelevant to them. The solution implemented called for commercial strategies to be implemented with monthly regional demand planning through integrated processes, analytical tools, and cross-department accountabilities. Having key business leaders actively involved in the process and the importance of organizational structure and communication were highlighted during this experience.

Value of a holistic approach to implementation of a fact-based analytics strategy – This was highlighted for a US-based pharmaceutical company during implementation of best practice solutions that used analytics to meet strategy, goals, and objectives. The importance of cross-functional interactions (rather than working in isolated silos) and communication to implement planning processes for value creation was evident during this exercise. As shown in Fig. 5.1, forecasting errors over a 10-year period for this company were reduced to 2% (from 20% previously), and

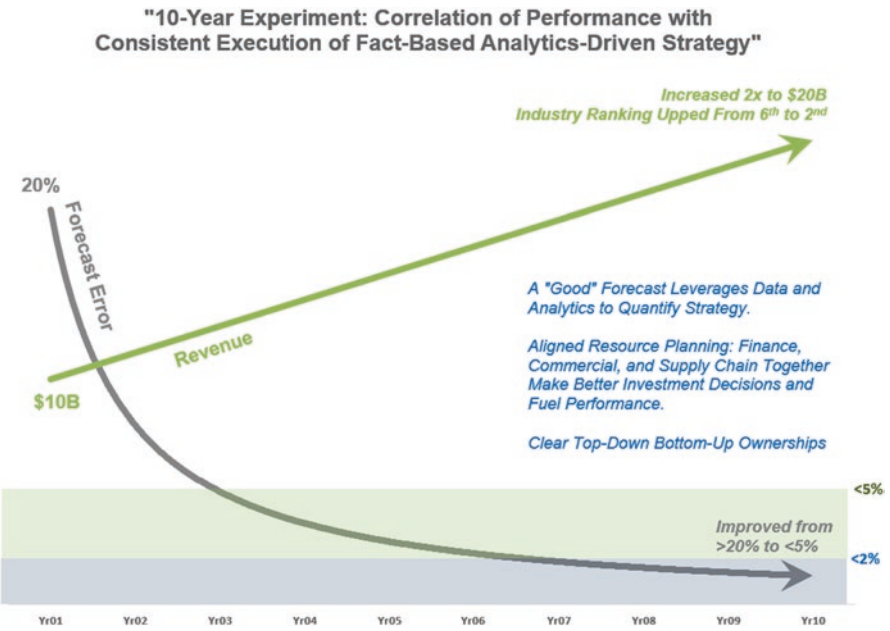

Fig. 5.1 Result of execution of analytics-based strategy

the company climbed to 2nd place (from 6th place) in industry rankings by implementation and execution of a fact-based analytics-driven strategy. Getting various functional areas like finance, commercial, and supply chain and operations to work together and align with company strategy was key to progress.

Previously, it was not uncommon for pharmaceutical companies to custom design and build in-house systems so that the right kind of data could be captured to develop insightful analytics and *improve forecast accuracies* so as to inform product management teams of opportunities and challenges. Today's software offerings address those gaps and add more capabilities. What was limited to, say, a single-country and offline application in the past can now be implemented across multi-countries enterprise and in real-time online. In addition, technologies such as business intelligence tools are also helping to close the analytics gap. These tools bypass the IT chasm and shorten the "distance" between the decision-makers and data while being able to surface information and analytics in much shorter time or in real time.

The key to success in practical implementation of data and analytics calls for using the right tools. During one implementation (Lee, 2016), Excel was selected to perform and integrate the analytics across a handful of entities. Conceptually, the logic and integration in the monthly process were straightforward. However, operationally, the time pressure and volume of disparate data involved became very cumbersome and eventually overwhelmed the analyst and led to resistance for a follow-up improvement project. Having the right tools that can easily and quickly accomplish otherwise cumbersome and mundane work can garner more support for

successful practical implementation. Software vendors also seem to have evolved into two camps – ones that start from scratch and develop advanced data mining capabilities in the software's foundation versus more established software vendors that still maintain traditional data management technologies but dress it up with a flexible user interface. The former group is more agile and holds promise in capabilities to extract newer insights.

Another area that is key to success in practical implementation of data analytics relates to gaining senior level support (Lee, 2016). While bottom-up on-the-ground support is important, top-down organizational support is key to success. Ultimately, people make the final planning decisions based on perspectives gained from their work experience. And while analytics could help to minimize the influence of biases in decision-making, real adherence to that desired practice depends on how directly and strongly senior management articulates and enforces the process and practice. The 10-year experiment, outlined in Fig. 5.1, occurred during a period when that organization's senior leadership strongly believed and articulated the use of a fact-based analytics practice for strategy development and implementation. Experience elsewhere where there is weaker senior management interest and/or support in the analytics-based decision-making practice seems to correlate with less stellar business performance.

This experience from consulting in the pharmaceutical industry and those outlined in surveys (Accenture, 2014) suggest that overall success comes from having an enterprise-wide strategy that uses data to drive business value. Embedding analytics in the day-to-day supply chain and operationalizing it rather than using analytics on an ad hoc basis are key to operational success. Another interesting finding is that as the three Vs of data – volume, variety, and velocity – keep increasing along with the complexity in supply chain, there is a feeling among supply chain leaders that their investment in analytics is not up to the mark and more investment in analytics is needed (Gartner, 2017). The reality, however, is that 50% of existing supply chain planning solutions in these organizations are not being utilized because these companies have not reached the higher levels of maturity required for more advanced analytics to be deployed (Gartner, 2017). These organizations need very basic levels of foundational capabilities like reports, dashboards, scenario, and statistical analysis tools in their toolbox for implementing requisite solutions. It is very important that these organizations look at the problem to be solved and business value that can be created by deploying supply chain analytics whether for managing production, operations, inventory, demand, or forecasting.

Case Study of Aligning Supply Chain Strategy with Data Analytics: AstraZeneca

AstraZeneca is a global, science-led biopharmaceutical company that develops innovative life-changing medicines. The scientific and data-driven approach is in full display across different functions across the company including supply chain. The evolution of supply chain (SC) and the use of analytics at AstraZeneca have

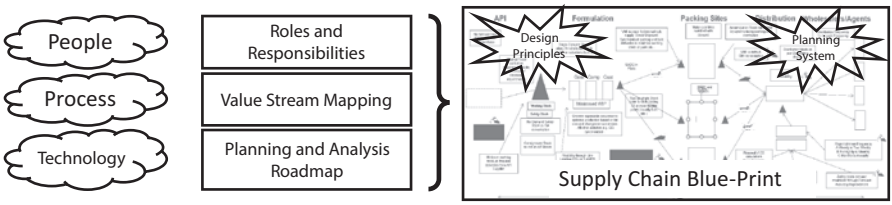

Fig. 5.2 Supply chain blueprint at AstraZeneca

been a journey. Significant progress has been made over the years, by thoughtfully evaluating the level of maturity and then implementing the right analytical technique to best support decision-making. Starting with simple and crude brute-force methods, the company has matured into using sophisticated data science for SC.

Data and analytics is used in various aspects of supply chain management, of which we are going to highlight a few vis-à-vis, developing the supply chain blueprint (SCBP), the way the company does it long range capacity planning, determines the right inventory levels, and its quest to improve velocity while decreasing variability.

The process of utilizing and developing a SCBP has to be underpinned by three key areas, people, process, and technology, as shown in Fig. 5.2. The people approach is an organizational structure and focuses on supply chain excellence matched with the capabilities to execute the SCBP strategies. Process means globally aligned and governed processes that are standardized and followed. Technology works as an enabler and needs to be a technology platform sufficiently developed and robust in capability that enables and supports the access of critical business data and analytics needed for supply chain excellence. On the people and process side, new roles were created; responsibilities, streamlines, and interactions formalized; and expectations clarified. On the technical side, technology platforms in modern supply chains serve an important enabling function. Without an end-to-end enterprise resource planning system implemented in conjunction with standardized process, most supply chains would be very difficult to coordinate and execute. These systems are enablers of key supply chain processes and allow resources and assets to be efficiently utilized while alerting supply chain planners to potential problems with their plans or schedules. Over the past 3 years, AstraZeneca has made a very large investment in upgrading and aligning all of their SAP implementations within AstraZeneca to be on a common platform to drive standardization of their supply planning and demand planning processes and provide system-wide visibility to inventory, capacity outlook, and key planning parameters. This upgrade also includes a global roll out of an APO (advanced planning and optimization) tool. Without this investment and the visibility it now provides, achieving much lasting change would be very challenging. This technology upgrade in conjunction with the value stream mapping (VSM), a LEAN process, and implementation of the SCBP has enabled tremendous savings in their supply chains. The key outcomes measured are inventory level reductions, improved total lead time, reduced stockouts, and improved risk management, reporting to show the benefits.

As the blueprint got embedded and more data was available, the company has over time started using statistical modeling for service level optimization by effective trade-off between cost and inventory. As a company that develops and supplies innovative medicines, the availability is extremely important as in most cases there is no alternative available to patients. To keep the medicines cost-effective to patients, the company uses a scientific approach to determine how much safety stock it should carry. Using product history, life cycle stage of the medicine, demand and supply variability, and desired customer service levels, the right inventory target is determined using a blend of statistical techniques. By being able to group products effectively, quantitative determination of cycle time and cycle time variability, analytically determined replenishment intervals, and use of safety formula, the company has achieved one of the best inventory performances in the industry. Today the company uses a custom tool for inventory optimization which has been developed as a bolt-on to SAP-APO, with ongoing work to implement MEIO capability using Llamasoft.

As the data maturity grew, the company initiated the use of data science in strategic supply chain decisions. In the highly regulated pharmaceutical industry, it is vital to operate as efficiently as possible to maximize the availability of high-quality medicines to patients at minimal cost. This starts with having the right manufacturing capacity and plans for the future. To support the changing product portfolio of the company, capital decisions needed to be made quickly while analyzing multiple options and scenarios. So, to help determine the long-term operations investment strategy, a blend of techniques using Monte Carlo simulation and an integer programming-based solution is being used. A dedicated team of experts evaluated different options and settled on Crystal Ball for Monte Carlo simulations and Llamasoft for capacity planning and optimization. They then collected detailed manufacturing data from the sites, which along with the 10-year demand forecast is used to develop and validate the base model. Then different scenarios were analyzed to evaluate potential impact of successes of different therapies, changes to demand volume and geographic distribution, impacts of divestitures and acquisitions, and impacts of expansion, consolidation, and rationalization of capacity. The rigorous analysis provides a reliable and consistent approach to future capacity planning. The model has been used to evaluate and recommend several network changes to best meet the long-term needs of the company and patients. The solution has not only highlighted potential financial benefit but has been instrumental in instilling a more conscientious data-driven approach to decision-making.

Another place where data science is seen in use at AstraZeneca is in how the company is improving the velocity with which products flow through the supply chain while reducing the variability in the process. The whole process of getting to the right information is a momentous task as there are large volumes of data distributed across multiple systems across the globe. With the distributed nature of the manufacturing process, a product might start at one site and go through different processing at multiple other sites. Integrating and deriving conclusions from this data that resides at these different locations with its own data specifications and nomenclature are a big data exercise. The information from different ERP systems is first accumulated in a data lake, and then different algorithms run to create relationship between the large volumes of manufacturing, shipping, and sales data, thus

determining the true velocity and variability in the process. Most of the data is processed through structured database built in Oracle and is visualized through QlikView. Having the standard way to process the data and then display the output is critical to diagnose the issues and make the results actionable. This information is then used to compare performance, identify opportunities, and track progress for the various velocity improvement plans. With these activities, the company has already reduced WIP and inventory by $200 million and expects further reduction of more than $500 million over the next 3 years.

Emerging and Future Trends

There are enormous opportunities available for pharmaceutical companies to link data and analytics to business value creation and performance improvement. A few examples opportunities are outlined (Champagne, Hung, & Leclerc, 2015) below:

- Research and development will involve more modeling and computer simulation techniques, to enhance organizational effectiveness.
- Marketing and sales will work to better understand customers including cures for rare diseases.
- More linkages of data within players in the pharmaceutical ecosystem will become commonplace as more digital tools will be used to evaluate best treatment options to meet outcome-based thresholds.

Bridging the Gap Between Theory and Practice

One way to bridge the gap between theory and practice is the use of future leaders programs. The opportunity to bring on new young talent and provide a supportive environment to allow these new recruits to evolve into future leaders is a challenge many pharmaceutical companies are facing. A creative and successful way some companies are dealing with this challenge is the use of a targeted program that enrolls recent college graduates into a controlled and focused future leaders development program. The first step in the success of these future leaders program is to bring in high-caliber graduates, with potential and ambition to become a future leader at the company. The use of a rigorous screening and hiring process that includes a behavior-based interview, case study, real-life problem-solving, and group interactions with other possible recruits ensures the pool of new hires is well qualified to meet the rigors of the 3-year future leaders program. Secondly, by ensuring each individual that enters the program has a home organizational sponsor and a senior level mentor, recruits' success rates are increased greatly. Additionally, the home organization "owns the head count" at the end of the 3-year program thus guaranteeing the recruit a role upon completion of the program if they have not landed a role or been exited from the program. By including this requirement, it allows the recruit to focus on

embracing the learning and developing experience and for delivering value in the roles they rotate through as well as ensures the home organization stays engaged with the recruit progress and success throughout the program.

In one pharmaceutical company's program, a key element of their future leaders program is leadership development. In the first 2 years, a recruit will be split between three different placements, and each role will give them valuable insight on how to influence decisions and provide an opportunity to learn how that area of the business operates and connects with other parts of the business. Each recruit will also spend a minimum of 3 months living and working abroad, to gain exposure to different cultures and ways of working, as a hands-on way to test and improve their ability to handle responsibility. Finally, the recruit will land a consolidation role that will be their final role in the program and becomes their first role as a full-time employee. By giving recruits a vital pharmaceutical industry exposure, this future leaders development program is the perfect springboard to a senior job opportunity within the company.

The future leaders development program approach provides a number of benefits to both the company and the recruits. First, and most importantly, this approach allows the new recruits to effectively transition into the corporate world from the academic environment in a supportive and controlled way. By placing these recruits into meaningful roles and rotating them through assignments over a 3-year period, the recruit gets a chance to better understand the career path they prefer to follow that is aligned with their aspirations and strengths. The company gets an extended period to determine which area of the organization the new recruit will have the best chance for future success or if they should be exited from the program. This much longer and more in-depth review and evaluation of a recruit's future potential ensures the best candidates are identified for retention and assigned the more challenging roles in areas that match their aspirations. This extended "grace" or "provisional" period helps both the recruit and the company ensure future success as a full-time employee and leader. Another organizational alignment benefit is the ability to match new young talent to areas of greatest organizational need due to organizational growth, introduction of a new business operating model, or shifts in business approach due to external business environment changes. This future leaders program approach also provides the new recruits early access to senior leaders in the company which promotes the accelerated development of leadership prospective and guidance on the path they may want to choose in their careers. Finally, the recruits benefit from the establishment a solid network with their counterparts in the program as well across many parts and levels of the organization with all the managers and employees they have worked with the 3-year program. This approach has promoted a much higher level of successful program completion and retention of future leaders and talent than other avenues or approaches.

Another way of bridging the gap between theory and practice is the establishment of Supply Chain Boards operated and managed by academic institutions and industry partners. By establishing these partnerships through a coordinated and structured approach that promote a shared responsibility for analyzing and studying industry practices and challenges, it allows for the application of academic theory in support resolution to these challenges and improvement of industry practices. Additionally,

the development of this synergistic relationship between academia and industry ensures the continuous access to critical feedback on how the theory and practices being taught apply to real-world challenges and practices. Additionally, it allows for ongoing collaboration and feedback for driving improvement through meaningful academia and industry programs, symposiums, and training events. This ensures the problems supply chain organizations are dealing with in the industry have a partner in academia that is looking at the best way to solve it. These Supply Chain Board partnerships also extend to undergraduate students, graduate students, and professors in very beneficial ways. It allows access to industry resources to funnel research questions and queries to as well as gather real-world feedback on new approaches and theories. It provides outlets for student project teams to study real-world supply chain challenges. It promotes a strong partnership to open up intern and future employment opportunities for graduating students. Bridging the gap between theory and practice is done best when both industry and academia partner in meaningful ways to make this happen.

Conclusion

As the pharmaceutical industry supply chain continues to evolve in its application of data and analytics, due consideration must be given to the strategy and culture of the organization. Defining the business case is vital, and understanding that analytics needs to be linked with business strategy is critical. As outlined in the case with AstraZeneca, successful pharmaceutical companies will have organizational structures and processes in place that make them agile and ready for the future. Winners will not be defined not by who are the strongest today but by those that are quickest to adapt (Fox, Paley, Prevost, & Subramanian, 2016).

The big data world we live in today has the tools and technology to speed access to voluminous data and rush them into analytic engines to turn into information and insights to business people involved in developing strategies. The opportunities are plenty, but caution is also prudent. In the past, "More Is Better" was a default business motto when generating analytical reports. However, to succeed in the business world today, a different motto, "Less Is More," is needed (Lee, 2014). Getting there involves weeding out irrelevant data from voluminous data sets, and this can be achieved only if we align business strategy with the right analytics.

References

Accenture Global Operations Megatrends Study. (2014). *Big data analytics in supply chain: Hype or here to stay?* Retrieved from https://www.accenture.com/t20160106T194441__w__/fi-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Digital_1/Accenture-Global-Operations-Megatrends-Study-Big-Data-Analytics-v2.pdf

AstraZeneca. (2017). AstraZeneca Website. Retrieved from https://www.astrazeneca.com/our-company.html

Champagne, D., Hung, A., & Leclerc, O. (2015). The road to digital success in pharma. *McKinsey White Paper*. Retrieved from http://www.mckinsey.com/industries/pharmaceuticals-and-medical-products/our-insights/the-road-to-digital-success-in-pharma

Chen, H., Chiang, R., & Storey, V. (2012). Business intelligence and analytics: From big data to big impact. *MIS Quarterly, 4*(36), 1165–1188.

Copping, R., & Li, M. (2016). Analytics: The promise and challenge of big data for pharma. *Harvard Business Review*. Retrieved from https://hbr.org/2016/11/the-promise-and-challenge-of-big-data-for-pharma

Fox, B., Paley, A., Prevost, M., & Subramanian, N. (2016). Closing the digital gap in pharma. *McKinsey White Paper*. Retrieved from http://www.mckinsey.com/industries/pharmaceuticals-and-medical-products/our-insights/closing-the-digital-gap-in-pharma

Gartner. (2017). *When – and when not – to buy additional analytical capabilities for your supply chain planning process*. Retrieved from https://www.linkedin.com/pulse/when-buy-additional-analytical-capabilities-your-supply-pradhan

Genpact. (2014). Supply chain analytics. *Genpact White Paper*. Retrieved from http://www.genpact.com/docs/resource-/supply-chain-analytics

Lee, A. (2014). *Big data: An inevitable paradigm shift and two impacts for pharma*. Philadelphia, PA: Digital Pharma East Summit.

Lee, A. (2016). Accuracy for profitability – Is this achievable? *CBO Bio/Pharma Product Forecasting Summit*, Philadelphia, PA.

Mayer-Schönberger, V., & Cukier, K. (2013). *Big data: A revolution that will transform how we live, work, and think.* New York: Houghton Mifflin Harcourt Publishing Company.

McAfee, A., & Brynjolfsson, E. (2012). Big data: The management revolution. *Harvard Business Review, 90*, 60–68.

Mentesana, M., Rotz, G., Strang, D., & Swanick, M. (2017). 2017 Pharmaceuticals and life sciences trends. *Strategy& White Paper*. Retrieved from https://www.strategyand.pwc.com/trend/2017-life-sciences-trends

Muhtaroglu, F. C. P., Demir, S., Obali, M., & Girgin, C. (2013, October). Business model canvas perspective on big data applications. In Big Data, 2013 *IEEE International Conference on* (pp. 32–37). IEEE.

Otto, R., Santagostino, A., & Schrader, U. (2014). Raid growth in biopharma: Challenges and opportunities. *McKinsely Quarterly*. Retrieved from https://www.mckinsey.com/industries/pharmaceuticals-and-medical-products/our-insights/rapid-growth-in-biopharma

PWC. (2017). Pharma 2020: Supplying the future. Retrieved from https://www.pwc.com/gx/en/pharma-life-sciences/pharma-2020/assets/pharma-2020-supplying-the-future.pdf

SAS. (2010). Supply-chain analytics: Beyond ERP & SCM. *SAS White Paper*. Retrieved from https://www.sas.com/resources/asset/SAS_IW_FinalLoRes.pdf

Statista. (2017). *U.S. pharmaceutical industry – Statistics and facts*. Retrieved from https://www.statista.com/topics/1719/pharmaceutical-industry/

Waller, M. A., & Fawcett, S. E. (2013). Data science, predictive analytics, and big data: A revolution that will transform supply chain design and management. *Journal of Business Logistics, 34*(2), 77–84.

Wamba, S. F., Akter, S., Edwards, A., Chopin, G., & Gnanzou, D. (2015). How 'big data' can make big impact: Findings from a systematic review and a longitudinal case study. *International Journal of Production Economics, 165*, 234–246 Retrieved from https://doi.org/10.1016/j.ijpe.2014.12.031

Wang, G., Gunasekaran, A., Ngai, E. W., & Papadopoulos, T. (2016). Big data analytics in logistics and supply chain management: Certain investigations for research and applications. *International Journal of Production Economics, 176*, 98–110 Retrieved from https://doi.org/10.1016/j.ijpe.2016.03.014