Predicting Technological Disruption

Actor Network Theory of the Capstone Project

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Systems Engineering

By
Adam Rogers

December 01, 2023

Technical Team Members:
Carter Dibsie
David Underwood
Ethan Kuzneski
Lauren Sullivan
Robert Brozey

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Joshua Earle, Department of Engineering and Society

Michael Porter, Department of Systems and Information Engineering

INTRODUCTION

Semiconductors are the single most critical component of modern electronics, which are used in communications, computing, healthcare, military systems, transportation, clean energy, and countless other applications. They are a clear technological disruption, they constantly sweep away old systems or habits and replace them because they have attributes that are recognizably superior (Smith, 2022). Semiconductors have become even more important over the past couple of years due to the data centric demand spike. This, coupled with the COVID-19 pandemic, has forced the semiconductor industry to the forefront of the global economy. From 2012 to 2022, global sales of semiconductor chips doubled to $602 billion, accelerated by increasing digitization and connectivity across nearly every industry (Congressional Research Service, 2023, p. 1).

From its inception, the field of semiconductors has attracted a great deal of capital from private groups, corporations, and government agencies (Kressel et al., 2010, p. 128). The demand for electronic devices and connected technologies only continues to grow. According to Moore's Law, the number of transistors on a microchip doubles roughly every two years. The constant performance improvements, energy efficiency, and miniaturization of semiconductors fuels the demand for newer and more advanced products. With that, the challenge for investors in the semiconductor industry lies in identifying these technological disruptions and taking advantage of their profitability.

Titus Technologies LLC, a business from Irondale, Alabama, has tasked our team of University of Virginia Systems Engineering undergraduate students with exploring the predictability of disruptive technology for our fourth year Capstone Project. The technical portion of this paper will review how that is being done. The STS portion of this paper will

explain the politics associated with this project between the company, faculty members at the University of Virginia, and us, the students engaged in this Capstone Project.

TECHNICAL PROJECT

As previously mentioned, semiconductor research, design, and manufacturing has been disrupting markets and society today, and will continue to do so in the future. These disruptions do not happen as randomly as it may seem. There are several components and factors that ultimately lead to the buildup of a market disruption. Our advanced economy gives way for a range of economic variables such as firm performance and technological specialization to play a large role in economic growth. The challenge lies in how to anticipate the disruption.

Breakthrough technology is often not purely a result of that technology itself, but rather a combination of other mature technologies that enable the disruptive ones to create the breakthrough. Innovation, which involves accumulating and consolidating existing technologies into new technologies is a natural process. However, the diffusion of knowledge plays an active role in shaping the direction of innovation and technical evolution (IGI Global, 2019, p. 2083). With that, these technologies likely have a history of published research that lays the groundwork for their capability. Something that is disseminated to the public long before a disruption occurs. Furthermore, there is commonly a chain of research, venture capital, and private equity funding that leads to the disruption. Lead investors, the number and type of funding rounds, and even a company's contacts may indicate a technological disruption is imminent. Technological disruptions may also be predicted from the social innovation networks that are formed. The right people in the right room collaborating is a catalyst for the sharing of skills, iterative development, and eventual technological breakthrough.

In short, the goal of the technical project is to explore the predictability of disruptive technology through studying the leading technology indicators, research and development funding, and associated social networks. Anticipated objectives for the technical project include:

1. Collecting open-source databases like Crunchbase and SEC filings that show where different funding entities were investing. Federal government databases such as the Federal Procurement Data System (FPDS) can show what basic research areas received money.
2. Examining academic publications and social network data to identify the innovation networks that lead to the disruptive technologies. Identifying researchers and companies that produced breakthroughs along with the dynamics of these networks.
3. Measuring the correlation of influx of research funding, venture capital funding, and private equity funding with respect to market disruption. Identifying patterns in technology development that lead to breakthroughs.
4. Ultimately building an open-source dataframe and a model to predict future disruptions.

Our metric for market disruption is a startup with a valuation greater than $1 billion. Companies that fall under this umbrella are known as “Unicorn Companies.” Our focus, as previously mentioned, is in all parts of the semiconductor industry from research to development to manufacturing and so on. Unfortunately, new market disruption is extremely difficult to spot. They often start small, drawing on early adopters with lower costs or simpler, more accessible products. The key attribute to recognize is that they increase the number of consumers or consumption occasions rather than stealing share from existing consumption (Bartman, 2015). This is something that our Capstone Project team will keep in mind when carrying out the study.

Unicorns exist at the intersection of people, investments, and companies. By storing this sort of data, the team hopes to build a network of connected information.

STS PROJECT

As with any tasking or service to be completed amongst multiple stakeholders, there exists several social dimensions. There are social interactions between client and student, between student and Capstone advisor, between Capstone advisor and department chair, and so on. There are social structures such as client and worker but also advisor and student or boss and employee. There are social norms and values; unwritten rules governing the behavior of individuals in the network. The list goes on. In this STS portion, I will demonstrate the social factors at work in the development of the technical project. I will do so by using the Actor Network Theory (ANT) framework.

In ANT, both humans and nonhumans form associations, linking with other actors to form networks. Both humans and non-humans have interests that cause them to act, that need to be accommodated, and that can be managed and used (Sismondo, 2009, p. 81). The ultimate aim of my STS research is to discover which actants benefit and which actants suffer in this ANT. While a completely symbiotic business relationship sounds ideal, it is nearly impossible. To get to this point, the following actions will take place:

1. Identifying human and nonhuman actants of the technical project and how they relate to one another to accomplish a shared goal.
2. Recognizing the heterogeneity of actants, acknowledging their differences in attributes, interests, and roles.
3. Exploring moments of controversy, conflict, and negotiation as well as moments of stability and consensus in the ANT.

4. Understanding vested interests in the success of the project and how rewards or compensation flows.
5. Evaluating what groups are moving forward with the development, to include who work is being done for and who it is being done to.
6. Looking for ethical or legal issues associated with agreements in the technical project.

I will gather the information to formulate this ANT through ethnography. A qualitative method for collecting data through observations and interviews, which are then used to draw conclusions about how societies and individuals function (IRB-STS). The most obvious actants to initially interview are Titus Technologies LLC. and us Systems Engineering students that are carrying out the technical project. We are the groups that are exchanging information, we form the client and worker social structure. From there, it may be necessary for me to interview other actants such as the Capstone advisor, Systems Engineering Department Chair, or even members of the Systems and Information Engineering Design Symposium (SIEDS). SIEDS is the academic conference that the technical project is presented to at its conclusion. These interviews however, only complete one side of the "anthropological triangle." The other two sides are comparison and contextualization, using these three sides can spur comparative theoretical reflection which can lead to deeper insight on what is really going on in the ANT. (Sanjek, 2013, p. 59).

To bolster the argument and better understand the role of students and universities in research, my STS portion will also look at how universities have become the center for research. Interestingly, the client came to us as university students with the tasking rather than a prestigious consulting firm. Universities are hubs, constantly facilitating the movement of ideas

and combining existing knowledge to create new things that support social benefit and economic growth (Owen-Smith, 2018, p. 118). This is precisely what the client is looking for.

The final area to research in my STS portion are the implications that the technological project may have on the world. In the event that the research and development being conducted becomes prosperous and lucrative, stakeholders involved will inevitably want a share. Conversely, in the event that the research and development being conducted becomes a massive failure, stakeholders may want their contributions back. Entrepreneurs may not be motivated primarily by pecuniary incentives. They are relatively more willing to forgo income and to bear costs, including through increased risk levels, in order to engage in independent ventures (Licht et al., 2005, p. 5). To this point, non-compete agreements, non-disclosure agreements, or any other similar contracts were not discussed at the onset of the technical project.

KEY TEXTS

While a majority of the information that is collected for the STS portion of this Prospectus comes from ethnographic research, it still requires an immense amount of independent research. That is where a majority of the time on the paper is spent. The key texts below help to not only support the claims made in the STS section, but also build the arguments. These four key texts, along with other pieces, will work in tandem to build my STS argument and the importance of the topic.

The first key text is a book that provides an overview of the field of Science, Technology, and Society. It is titled "An Introduction to Science and Technology Studies." Chapter 8, titled "Actor Network Theory," introduced the key theoretical framework that is used to evaluate the interconnectedness of human and nonhuman actors in the technical portion of the paper. It

emphasizes the importance of these connections and their ability to shape technological and scientific developments (Sismondo, 2009).

The second key text is a book that explores the practice of ethnography in today's society. It is titled "Ethnography in Today's World: Color Full Before Color Blind." Chapter 4, titled "Ethnography," includes a brief history of the science and its evolution over time. Ethnography is a product (writings) and a process (fieldwork) that is constantly overwritten. They stimulate comparative theoretical thinking, which in turn suggests new problems and interpretations to be resolved through further ethnographic fieldwork (Sanjek, 2013).

The third key text is a book that demonstrates what universities have to offer as centers of research. It details their central role in research and knowledge creation due to their mission, cultural and intellectual hub, access to resources, and more. It is titled "Research Universities and the Public Good: Discovery for an Uncertain Future." The book suggests that universities are the key to the creative economy. But the university requires the surrounding community to exploit the innovation and technologies that the university produces (Owen-Smith, 2018).

The fourth and final key text is a dissertation that explains how the level and modes of entrepreneurial activity are affected by the surrounding culture and legal rules. It is titled "The Social Dimensions of Entrepreneurship," and does this by showcasing a series of social studies on entrepreneurs in the early 2000s. Its conclusion states that entrepreneurs have a unique capability to overcome deficiencies by relying on social networks and resource sharing (Licht et al., 2005).

REFERENCES

Bartman, T. (2015, November 9). *Confronting a New Market Disruption*. The Forum for Growth and Innovation. https://www.hbs.edu/forum-for-growth-and-innovation/blog/post/confronting-a-new-market-disruption-disruptor

Congressional Research Service, Singh, M., Sargent, J. F., & Sutter, K. M., R47508 Semiconductors and the Semiconductor Industry 1–31 (2023, April 19).

Information Resources Management Association, & Ebook Central IGI Global EBA - 0 (2020). Disruptive Technology: Concepts, Methodologies, Tools, and Applications. Hershey, PA: IGI Global Business Science Reference (an imprint of IGI Global).

Kressel, H., & Lento, T. (2010). Investing in Dynamic Markets: Venture Capital in the Digital Age. Cambridge University Press.

Licht, Amir & Siegel, Jordan. (2005). The Social Dimensions of Entrepreneurship. The Oxford Handbook of Entrepreneurship. Oxford University Press.

Owen-Smith, J. (2018). Research Universities and the Public Good: Discovery for an Uncertain Future. Stanford, California: Stanford Business Books.

Sanjek, R., & Ebook Central - Academic Complete (2014). Ethnography in Today's World: Color Full Before Color Blind. Philadelphia: University of Pennsylvania Press.

Sismondo, S. (2010). Chapter 8: Actor Network Theory. In *An Introduction to Science and Technology Studies* (Second, pp. 81–93). essay, Wiley-Blackwell.

Smith, T. (2022, April 2). *Disruptive Technology: Definition, Example, and How to Invest*. Investopedia. https://www.investopedia.com/terms/d/disruptive-technology.asp

University of Virginia Vice President for Research. (2023). *Ethnographic Research*. IRB Social and Behavioral Sciences (IRB-SBS). https://research.virginia.edu/irb-sbs