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SIMULATING RECOVERY STRATEGIES TO ENHANCE THE RESILIENCE OF A SEMICONDUCTOR SUPPLY NETWORK

Yilin Chen, Thomas Ponsignon, Roland Weixlgartner, Hans Ehm

Infineon Technologies AG
Am Campeon 1-12
Neubiberg, 85579, GERMANY

ABSTRACT

Enhancing supply chain resilience is of vital importance in today's business to manage and mitigate the risks, especially in the semiconductor industry challenged with intrinsic long cycle times and short product life-cycles. Transferring production from a primary site to an alternative site after a disaster is one of the strategies to ensure resilience of the supply network. In this study, different types of alternative sites with various levels of preparedness are investigated. A discrete-event simulation is used to evaluate their operational and financial impacts under four different disruption scenarios. The simulation outcomes demonstrate unexpected positive benefits of various alternative sites in terms of fast recovery and resilience building.

1 INTRODUCTION

The world is exposed to all sorts of vulnerabilities and uncertainties. Over the last decades, many unpredictable catastrophes have been witnessed such as earthquakes, computer virus attacks, etc. When disasters occur, supply chains have the tendency to break down, which takes a long time to restore. Massive economic losses from supply chain (SC) disruptions follow. Under this context, supply chain resilience is at the heart of current SC management thinking. SC resilience emphasizes the adaptive capability to absorb the impacts from disruptions, respond to and recover from them. Having resilient SCs is of vital importance for the semiconductor industry, challenged by a widely spread supply network with long cycle times, short product life-cycles and changing technologies, as well as industries using semiconductors.

2 CASE STUDY: RECOVERY STRATEGIES FOR ALTERNATIVE SITES

Infineon is a leading semiconductor manufacturer with an agile but complex supply network. The products are manufactured in designated frontend and backend sites. In order to produce particular products in an alternative site, special equipment and technologies are required before the product transfer. This process is time-consuming, which makes it challenging to use an alternative site following a disaster. A semiconductor fab usually manufactures several technologies, with many products on each of the technologies. For model abstraction we simplified to one technology and few products.

As a result, four different types of alternative sites, i.e., mirror site, hot site, warm site, and cold site, are proposed to enable fast recovery. They are normal operating sites but they have different levels of preparedness for producing specific products (shown in Table 1). The type of alternative site is PG-specific. As seen in Table 1, from cold site to mirror site, the time to respond after a disruption gets faster because it is ready to use with tools and technologies, etc. Hence one may tend to demand a mirror site for their products. However the limited capacity and expensive investment upfront pose barriers to applying mirror site for all products. A simulation model is developed to assess the overall impacts and their trade-offs.

Table 1 Different Types of Alternative Sites

Class	Strategy	Readiness				Responding time
		Working cleanroom	Equipped with tools	Technology qualified	Product qualified	
I.	Cold site	Y				Slow
II.	Warm site	Y	Y			Medium
III.	Hot site	Y	Y	Y		Fast
IV.	Mirror site	Y	Y	Y	Y	Very fast

3 SIMULATION EXPERIMENTS

As shown in Table 2, four disruptions scenarios, i.e. strikes, infrastructure destruction, industrial accident and long-term cyber-attack, with different disruption lengths and severity are defined to study a broad range of situations regardless of their likelihoods. One product (P1) and three PGs (P2, P3, P4) are examined as a sample. Their corresponding alternative sites are tested under each level and disruption scenario. In total, 44 experiments are performed. The fill rate recovery time is the key operational measurements of SC resilience while the financial performance mainly includes the investment cost and Infineon cost (i.e., backorder cost, multiple costs at customer and customer of customer at long disruptions, and sales loss).

Table 2 Selected Disruption Scenarios

Scenario	Classification	Severity (Capa. loss)	Disruption Length (week)	Exp. Recovery Time after incident	WIP Left	Example
1	Strikes	90%	short	short	Y	Workers strikes, political strikes
2	Infrastructure destruction	100%	short	long	N	Earthquakes, hurricanes, floods, fires
3	Industrial accident	75%	medium	medium	Y	Gas leakage, polluted water
4	Long-term cyber-attack	40%	long	medium	Y	Computer viruses, tools damaged, time for buying new tools

The simulation is developed in AnyLogic, comprising three key features. Firstly, the demand and supply management module, in line with the internal logistic process mentioned above, takes care of the fulfillment of customer demand and tracks the accumulation of backorders. Secondly, the production disruption exerts the impact of a specific scenario, and the ramp-up process models the corresponding restoration phase, which is further validated by the experts. Lastly, the work-in-progress (WIP) is processed separately after a disruption with the identification of scrapping situations.

4 CONCLUSIONS AND FUTURE WORK

As expected, the mirror site has the fastest recovery at extremely high expense. A hot site could be a good alternative for mirror site, showing robust and excellent overall performance. Unexpectedly, a warm site has also satisfying results, except for short-term disruptions like strikes. Further beyond the anticipation, the cold site exhibits some achievements, especially for shortening the recovery time in long-term disruptions (e.g., infrastructure destruction). Nevertheless, it is not cost-effective to cope with short-term disruptions. Those findings can be used to support the determination of alternative sites. Furthermore, the simulation demonstrates the tangible benefits of non-mirror sites for ease of discussion with customers.

As a next step, the scope could be extended to end-to-end SCs with more dynamic disruption scenarios and to a more complex manufacturing setup. Furthermore, there is a need for a model to support design decision for a resilient SC network instead of focusing only on the recovery after the occurrence of a disaster.