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FORECASTING SUPPLY CHAIN IMPACT BY PREDICTING GOVERNMENTAL DECISIONS IN THE COVID-19 PANDEMIC

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ABSTRACT

During the pandemic, Infineon's supply chain impacts were largely defined by governmental decisions that affected transit times. Later, one of the major impacts came from demand reductions for semiconductors. Therefore, a System Dynamics (SD) Model that investigates the interdependence between infections and governmental strictness in restrictions using an extended SEIR model was developed in AnyLogic. For the quantification of governmental measures, the Oxford Blavatnik University coronavirus government response tracker was used. Based on this conceptual output, the resulting transit time increases have been connected with the strictness of these measures. The model links reductions in semiconductor demand to the duration of lockdowns as indicated by the current measures. The findings show that demand shocks and transit time delays can be buffered using flexible capacities and safety stocks.

1 INTRODUCTION

In this paper, the consequences of the COVID-19 pandemic in the supply chain of semiconductor manufacturers with a focus on Infineon Technologies AG are discussed. As COVID-19 spread, governments reacted by enforcing lockdowns and hygiene precautions to protect people’s health. Semiconductor manufacturers faced impacts on transit times often due to border closures and lockdowns. For this reason, an extended SEIR simulation model using SD modelling was created in AnyLogic that also addresses the interdependence between reported COVID-19 cases and governmental stringency levels. Additionally, one major long term impact from the COVID-19 pandemic will be decline for semiconductor and electronic equipment demand. For this reason, the SD model in question also investigates impacts on semiconductor demand by analyzing the interdependence between GDP and the duration of governmental decisions in the COVID-19 pandemic as an intermediate step and concluding from the GDP to revenue impacts in the semiconductor industry.

2 METHODOLOGY

First, an epidemiological model was implemented into AnyLogic. Most commonly described is the SIR model. There, susceptible people (S) become infectious (I) and after convalescence recover (R). In order to also be able to incorporate governmental measures that curb the spread of the disease, a broadly extended version of the SEIR model is used so that it reflects upon COVID-19 disease specifics and model the epidemiological progression of China. The SEIR model includes an exposed state (E) referring to infected people that have no clinical signs yet. The authors examined the interaction between governmental measures and infections in a very extensive way and was therefore chosen for the basis of the further model. In order to compare the severity and strictness of the governmental restrictions due to the virus, the Blavatnik School of Government created the Oxford COVID-19 Government Response Tracker. They evaluate 18 indicators and aggregate them into one final stringency index (stringency level). This was used as an input in the extended version of the SEIR model for the measures. To create a forecast, for the countries analyzed, the connection between the Oxford stringencies and the new reported COVID-19 cases for each day has been investigated and used as an input by making the measure variable dependent on the epidemiological model output. Regarding the estimation of the impacts of COVID-19 on an economic index like the GDP, this was obtained from the findings of reports in which the GDP decline of Germany have been quantified according to the duration of lockdowns. The measure values in the model have been classified as lockdown phase if they are above a certain threshold and the days spent in lockdown per quarter indicate how much the GDP will decrease. In order to be able to roughly estimate demand impacts, first, a dataset with German GDP growth rates per year and the yearly revenue growth rates of Infineon from German customers was created and a function was created. For the transit time impacts, real transit time data from calendar week 10 to 14 was analyzed and classified into three different impact scenarios. The impacts have been tested in an aggregated supply chain network consisting of a supplier, one frontend node, two backend nodes and a customer node. The KPIs monitored are inventory levels, cycle time, backlogs in backend facilities and demand fulfilment. For each node an information flow and a goods flow have been modelled. The goods flow considers production and transit times while the information flow addresses information distortions between actual demand and forecasts.

3 RESULTS

The discussion of the impacts are discussed based on graphs depicting the previously mentioned KPIs. Both the output of the epidemiological model as well as the demand analysis match the historic data sufficiently well. For most countries, the stringency levels as well as the cases show the typical wave pattern. For the German market case, there could be another dip in demand in the next Q1. Demand impacts for the most part influence stock levels. Delays in transit times do not affect the supply chain dynamics in the model very strongly. Low order fulfilment rates can be the result of a demand recovery that cannot be met due to insufficient stocks. This can be avoided by increasing desired stock levels. Also the possibility of shifting orders to other backend facilities with flexible capacities were an effective way to address the impact.

4 CONCLUSION

The interrelation between supply chain impacts in the semiconductor industry and governmental restrictions put into place because of the COVID-19 pandemic, focusing on demand impacts and transit time increases has been investigated by building a System Dynamics Model in AnyLogic. The COVID-19 pandemic is a special type of supply chain disruption. The forecast of measures using an extended epidemiological model could help with risk detection. Being able to meet recovered demand is a special challenge, while transit time increases seem to have relatively small impact. In order to ensure good demand fulfilment, flexible capacities and inventory levels are effective countermeasures. As the topic is complex with various interactions, accurate predictions are difficult and the results presented depend on the model assumptions that have been chosen.