

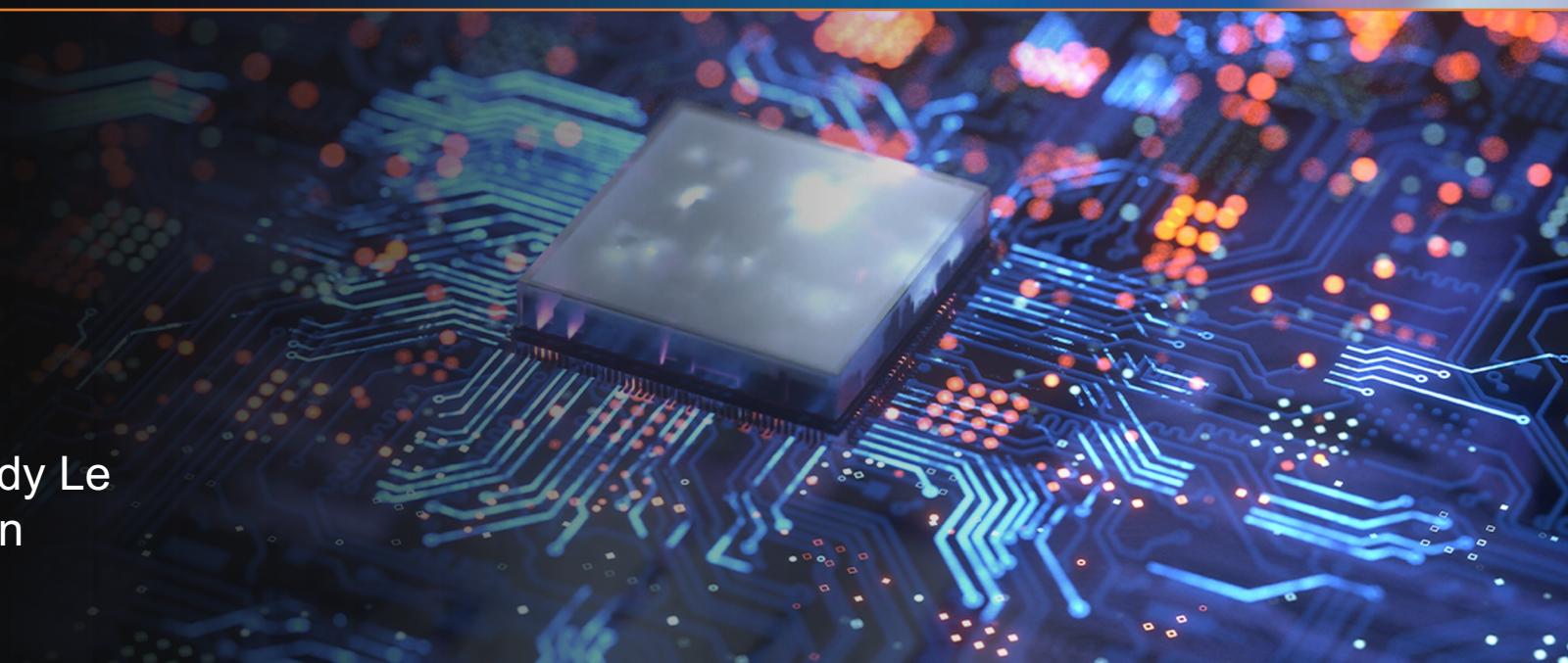
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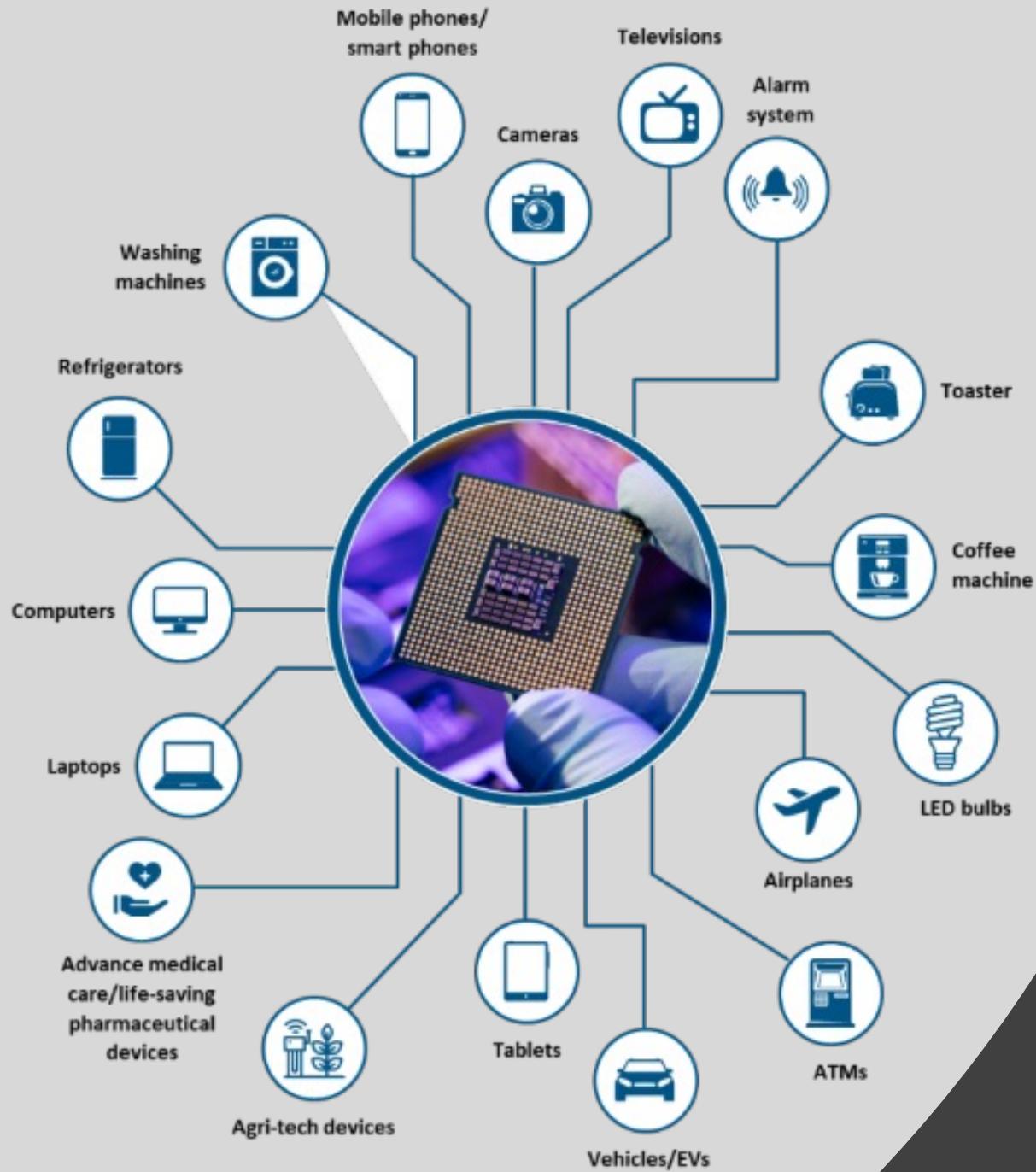
June 10, 2022

Automotive Semiconductor Supply Chain Analysis

Mitigating COVID-19
Disruptions in the
United States and
South Korea

Carlos Guzman – Euidam Kim – Cody Le
Janghoon Yu – Professor Ilyas Ustun





Semiconductors are everywhere and in everything:

- 25% Smartphones
- 20% Personal Computers
- 20% Electronics
- 15% Servers & Data Storage
- 10% Automotive

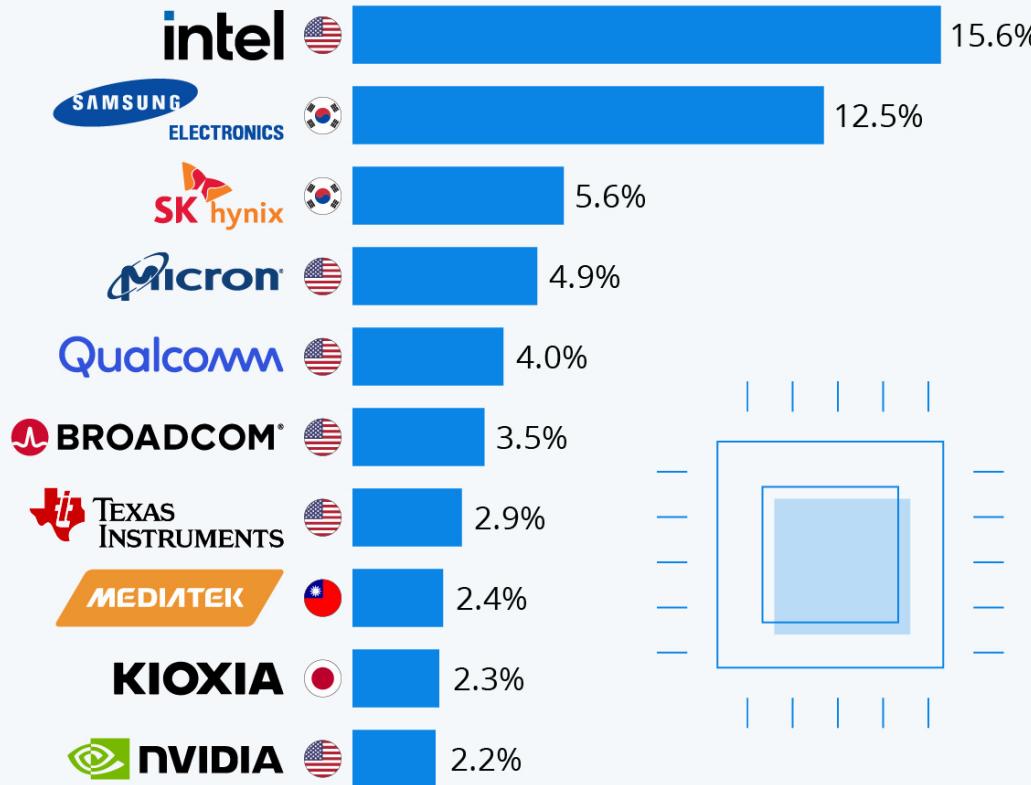
World's 4th Most Traded Product.

The average car is packed with 1,400 semiconductors or 'chips' that control everything from airbags to engine.

*Source: Detroit Free Press, Statista 2021

Intel and Samsung Lead Global Semiconductor Production

Market shares of the world's biggest semiconductor producers in 2020



Source: Gartner



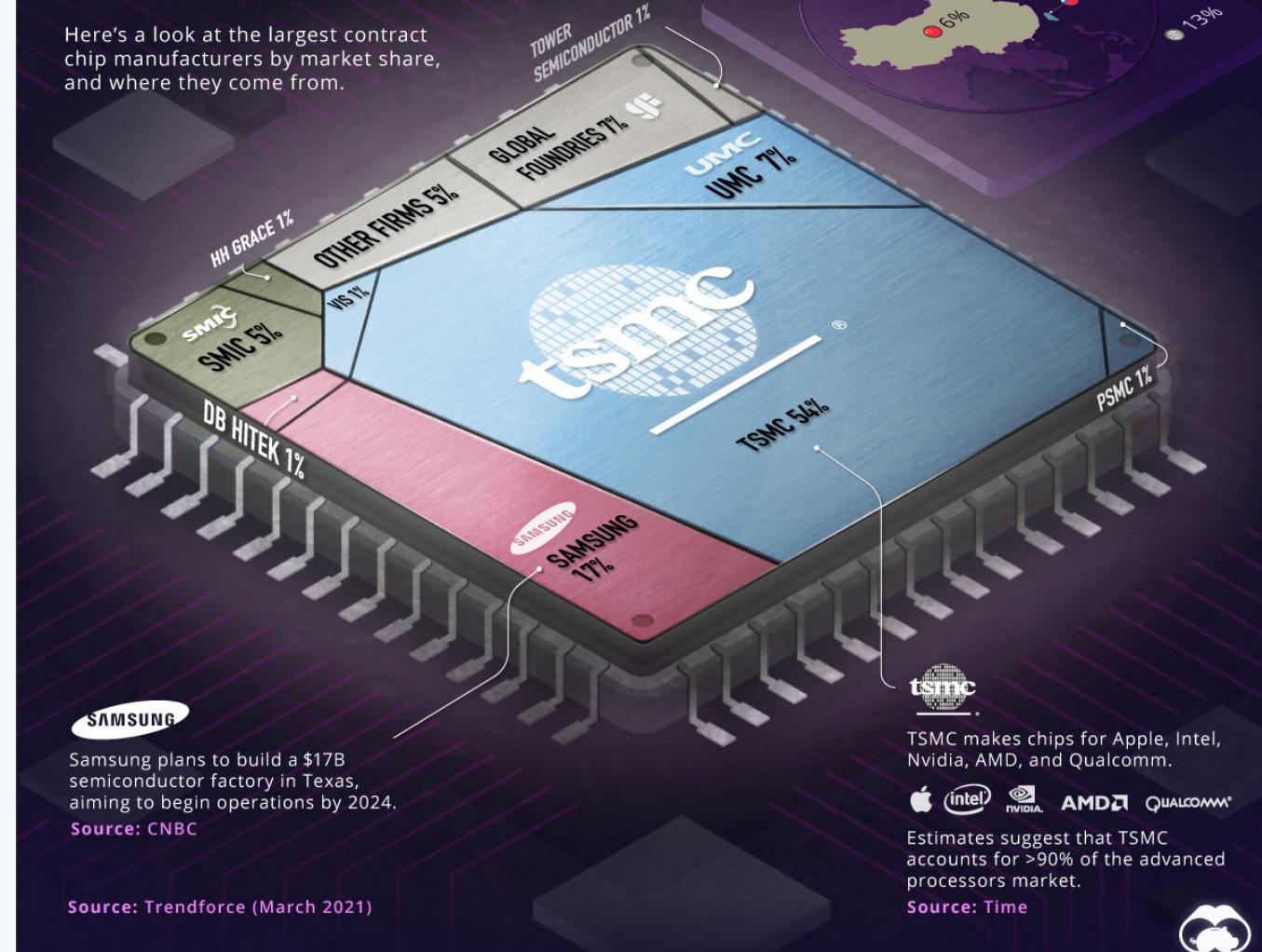
statista

VISUAL CAPITALIST DATASTREAM

WHERE SEMICONDUCTORS ARE MADE

From automobiles to computers, the global semiconductor chip shortage has rattled various industries.

Here's a look at the largest contract chip manufacturers by market share, and where they come from.



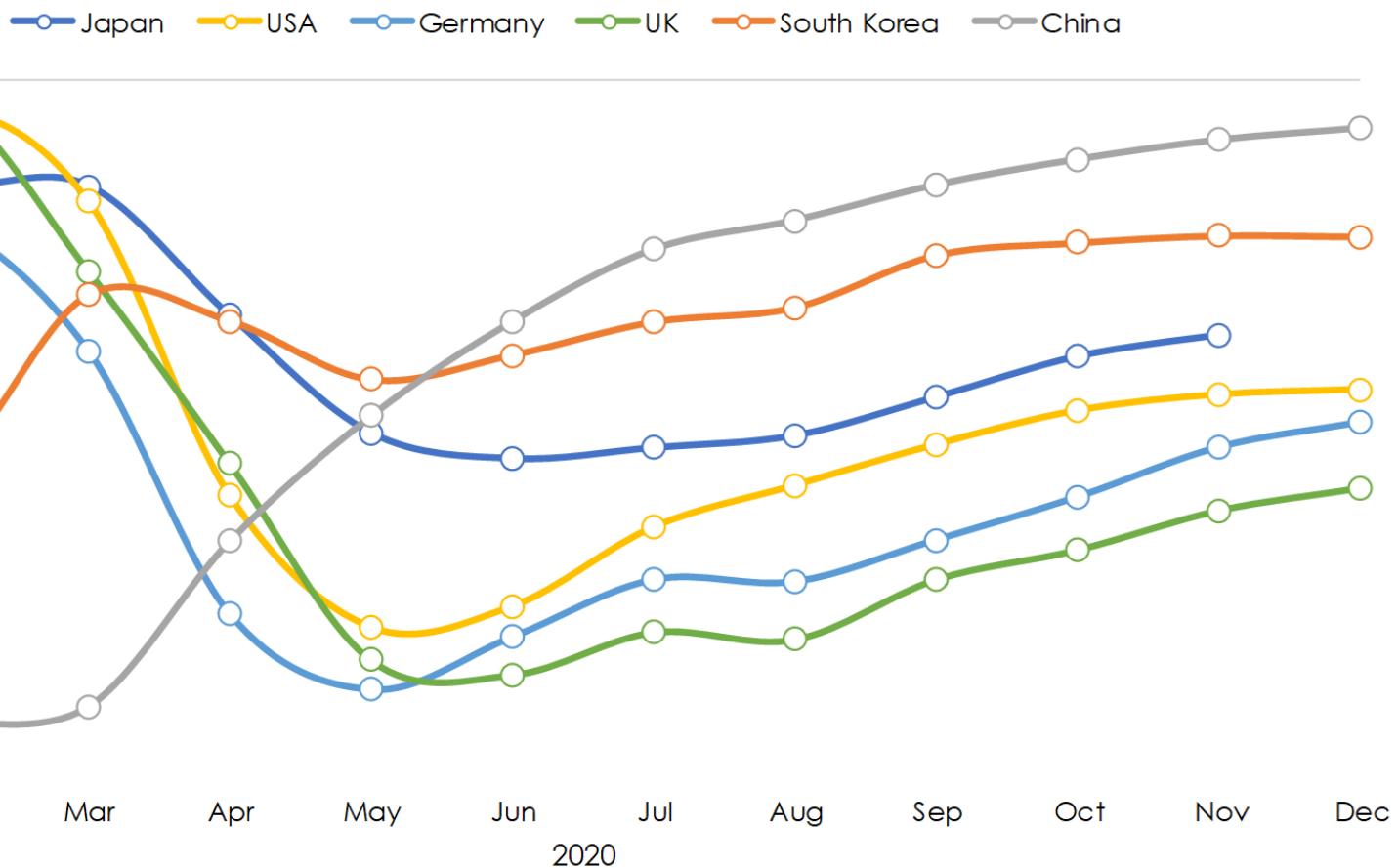
Automotive Semiconductor Supply Chain



TSMC make up 54% and Samsung make up 17% of Manufacturing Production

Did lower levels of production of semiconductors directly affect automotive production?

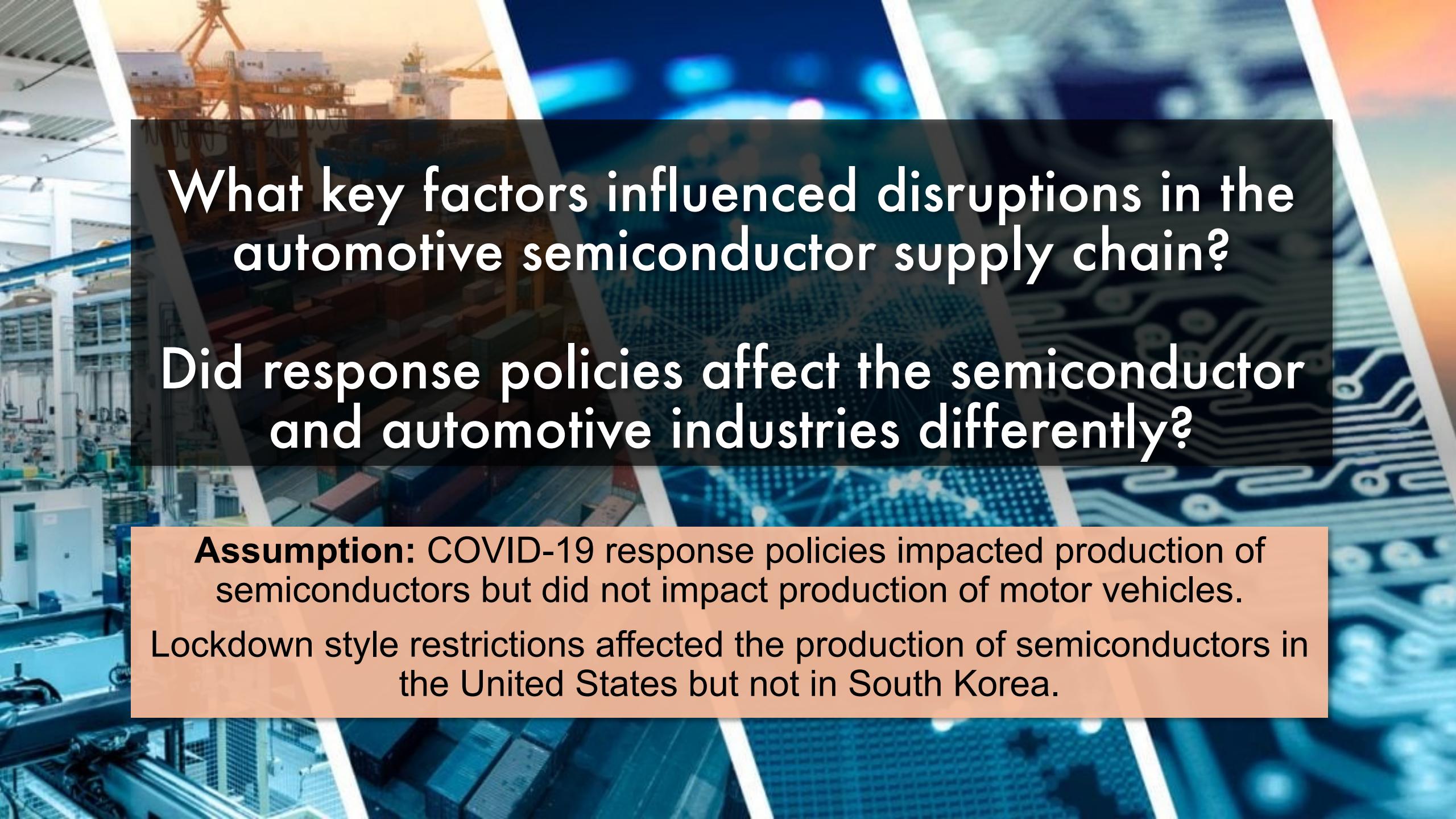
Global Car Production



*Source: Datium Insights, 2021 and Global Market Insights, 2022

TOP 6 CHALLENGES OF THE AUTOMOTIVE INDUSTRY POST-COVID ERA





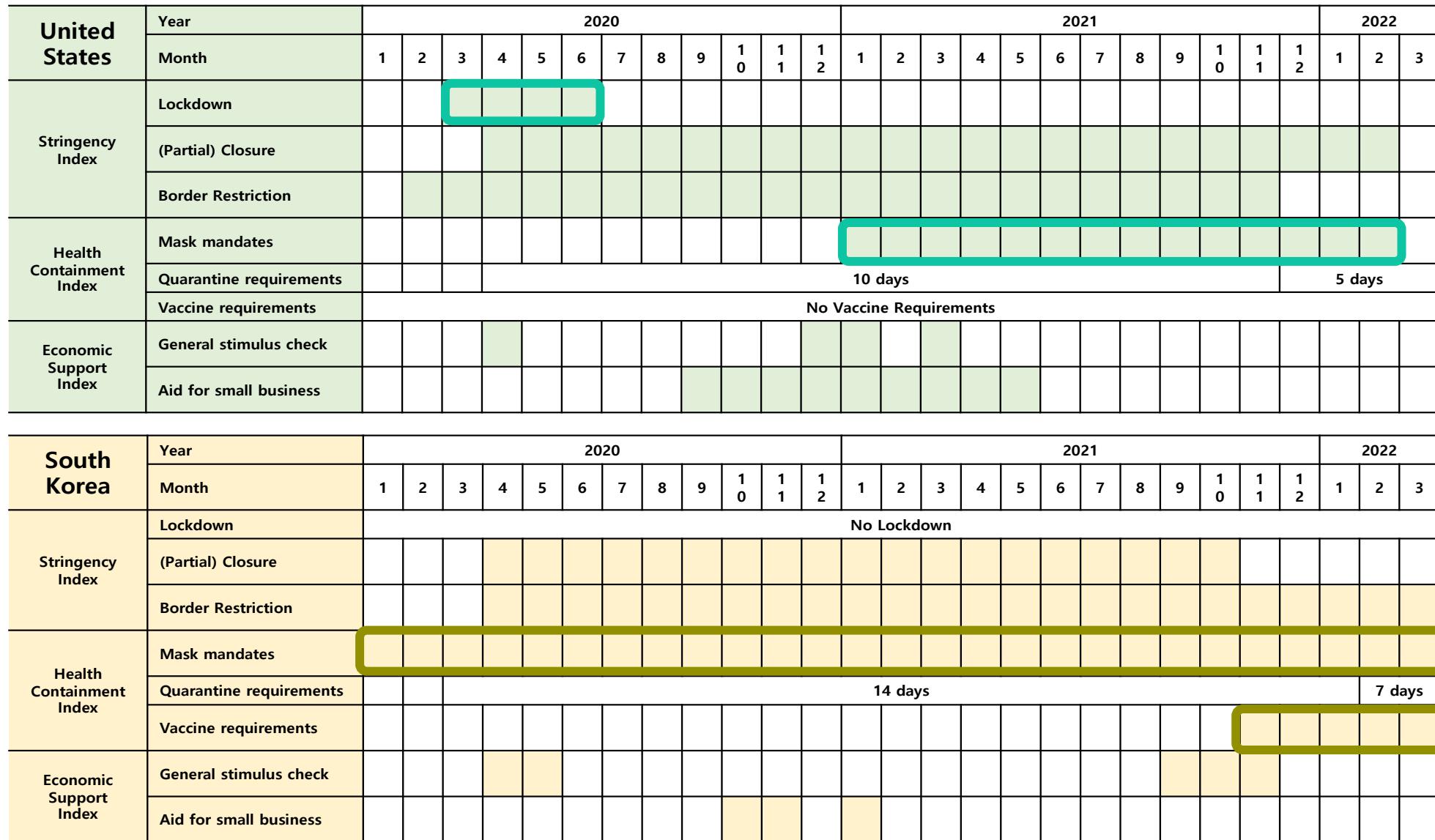
What key factors influenced disruptions in the automotive semiconductor supply chain?

Did response policies affect the semiconductor and automotive industries differently?

Assumption: COVID-19 response policies impacted production of semiconductors but did not impact production of motor vehicles.

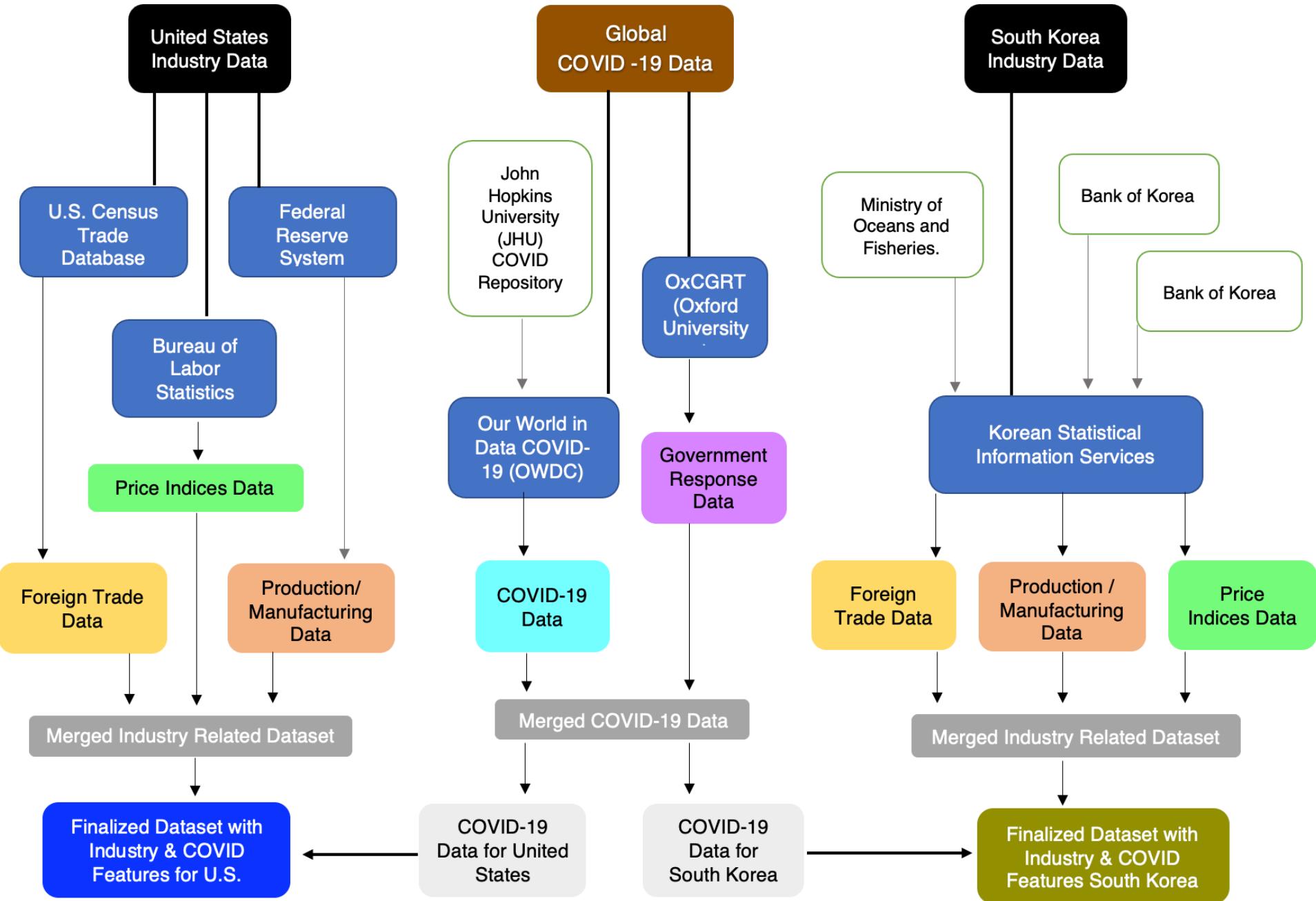
Lockdown style restrictions affected the production of semiconductors in the United States but not in South Korea.

COVID-19 Mitigation Policy Comparison



Data Source & Preparation

Trade
Production
Price Indices
Covid-19
Government Response



— Analysis:

Determine if covid features can predict trade, production, or price indices.

1

Use machine learning techniques to determine salient features for prediction.

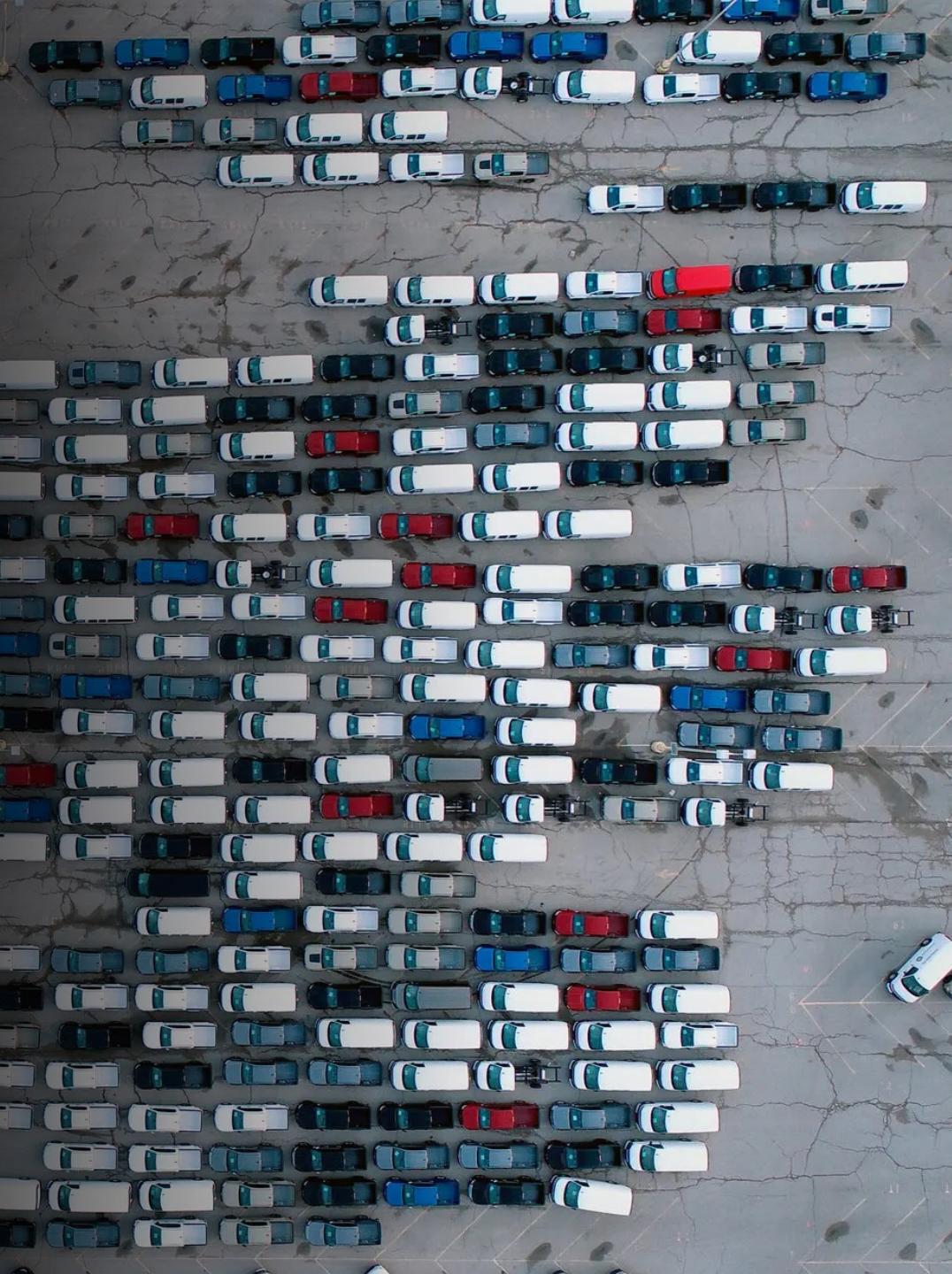
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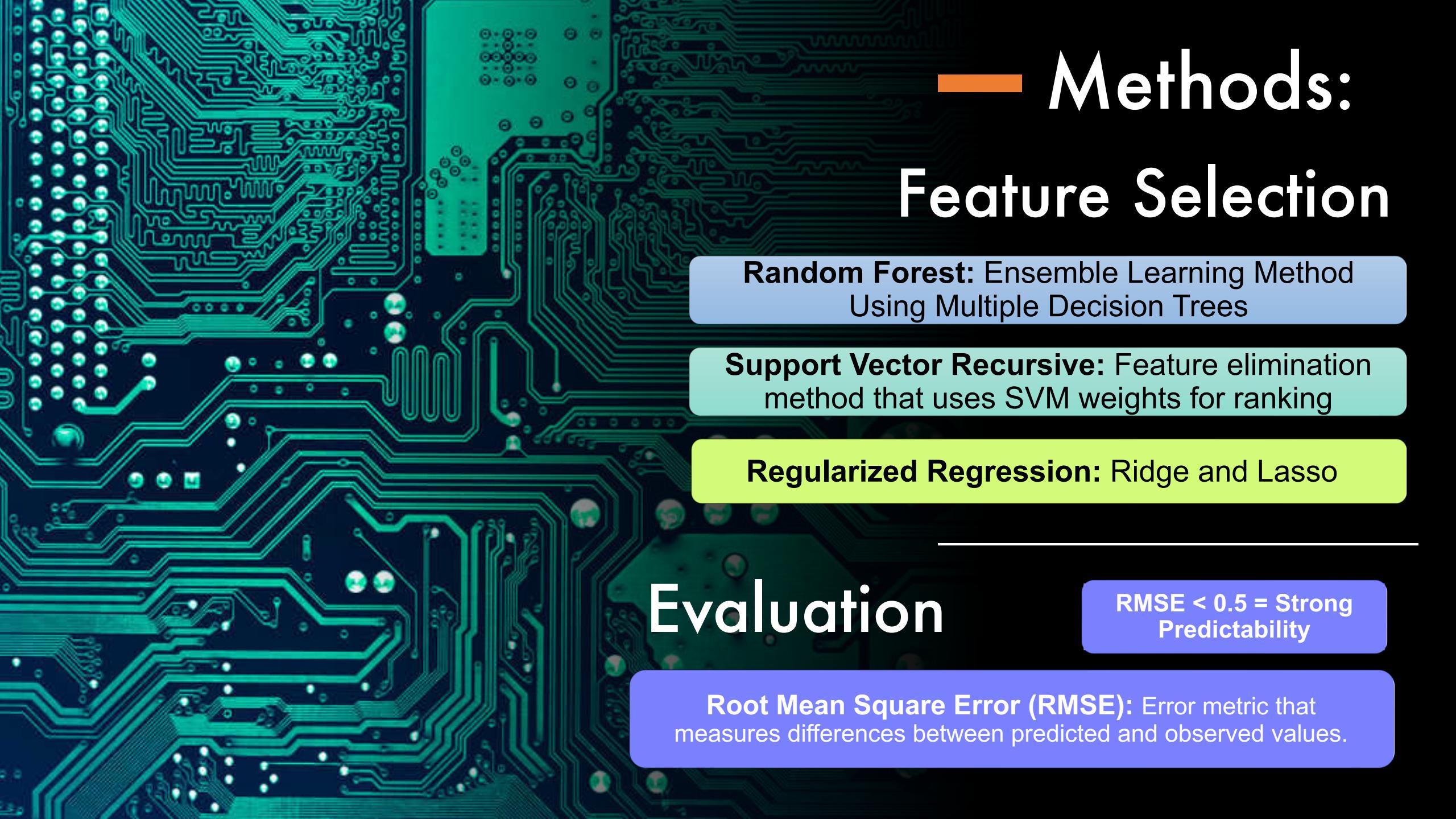
Use selected features in a GRU network for forecasting and future projections.

3

Apply projections to user-interface for government and industry use for future policy and decision making.

4





Methods:

Feature Selection

Random Forest: Ensemble Learning Method Using Multiple Decision Trees

Support Vector Recursive: Feature elimination method that uses SVM weights for ranking

Regularized Regression: Ridge and Lasso

Evaluation

RMSE < 0.5 = Strong Predictability

Root Mean Square Error (RMSE): Error metric that measures differences between predicted and observed values.

Feature Selection Results:

Semiconductors

Method and RMSE	USA			KOR		
	IP	ICAP	PPI	IP	ICAP	PPI
RF w/ Ridge	0.09	0.04	0.25	0.77	0.84	0.94
RF w/ Random Forest Regressor	0.21	0.16	0.46	0.39	0.08	0.83
Lasso	0.16	0.13	0.26	0.42	0.15	0.90
SVR	0.19	0.23	0.29	0.36	0.63	1.10

Random Forest (RF) with Ridge Regression best to predict for U.S. and with RF Regressor best to predict for South Korea.

* **Industrial Production (IP):** Volume of Production Output

* **Industrial Capacity (ICAP):** Resources at entity that enables production of goods.

Random Forest with Ridge Regression best to predict for Both U.S. and South Korea. Models could not accurately predict IP.

* **Producer Price Index (PPI):** Average change over time in selling price received by domestic producers for their outputs.

Motor Vehicles

Method and RMSE	USA			KOR		
	IP	ICAP	PPI	IP	ICAP	PPI
RF w/ Ridge	1.86	0.37	0.09	0.78	0.49	0.11
RF w/ Random Forest Regressor	1.17	0.65	0.15	0.90	0.74	0.22
RF w/ Lasso	1.13	1.42	1.5	1.1	0.43	0.90

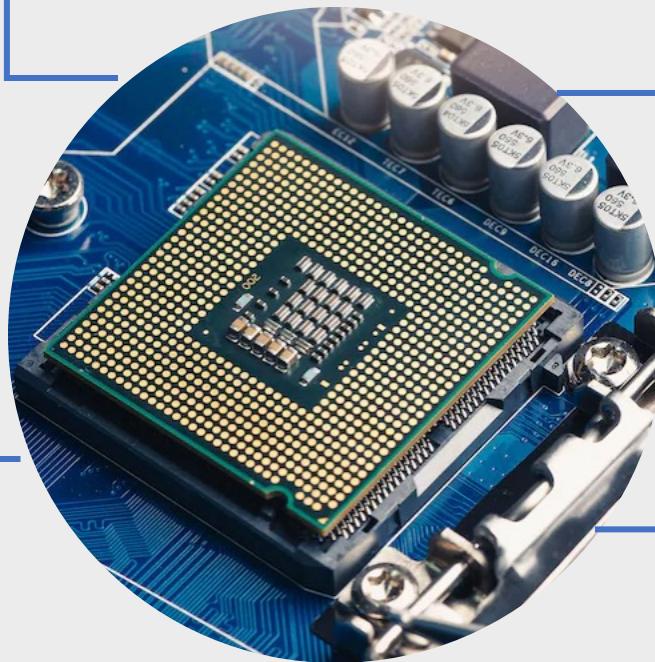
Comparison of Selected Features

--- Features Selected ---	Semiconductor						Motor Vehicle						--- Features Selected ---	
	USA Semiconductor			KOR Semiconductor			USA Motor Vehicle			KOR Motor Vehicle				
	IP	ICAP	PPI											
	8	10	6	12	9	4	5	10	10	8	9	14		
Exports MotorV													Exports Semi	
Imports MotorV													Imports Semi	
IP MotorV													IP Semi	
CAPUTL MotorV													CAPUTL Semi	
ICAP MotorV													ICAP Semi	
PPI MotorV													PPI Semi	
EPI MotorV													EPI Semi	
IPI MotorV													IPI Semi	
Total Cases													Total Cases	
New Cases													New Cases	
Total Deaths													Total Deaths	
New Deaths													New Deaths	
ICU Patients													ICU Patients	
Total Tests													Total Tests	
New Tests													New Tests	
Positive Rate													Positive Rate	
Total Vaccinations													Total Vaccinations	
People Vaccinated													People Vaccinated	
People Fully Vaccinated													People Fully Vaccinated	
Total Boosters													Total Boosters	
New Vaccinations													New Vaccinations	
Stringency Index													Stringency Index	
Government Response Index													Government Response Index	
Containment Health Index													Containment Health Index	
Economic Support Index													Economic Support Index	

Key Takeaway from Results

**COVID Factors
Can Predict:
Production
and Capacity of
Semiconductors**

**COVID Factors
Can Predict:
Capacity of
Motor Vehicles**



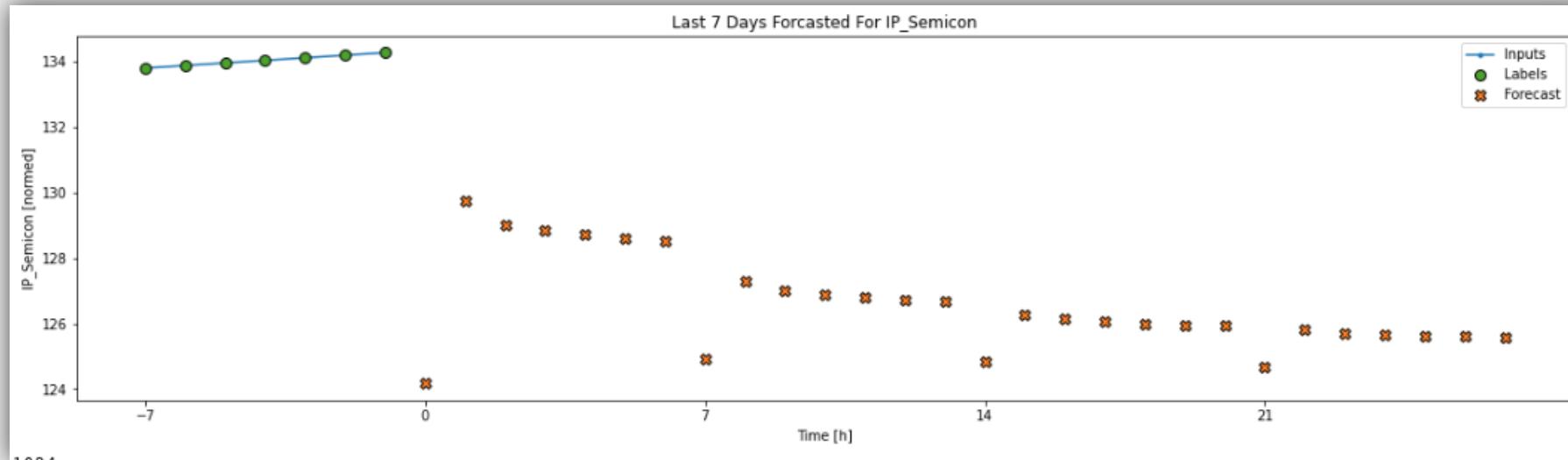
Response Policies:

- Not important for determining production and capacity of semiconductors

U.S. & Korea Comparison:

- Testing important for South Korea compared to U.S.
- Vaccinations important for both countries

Forecasting and Projections



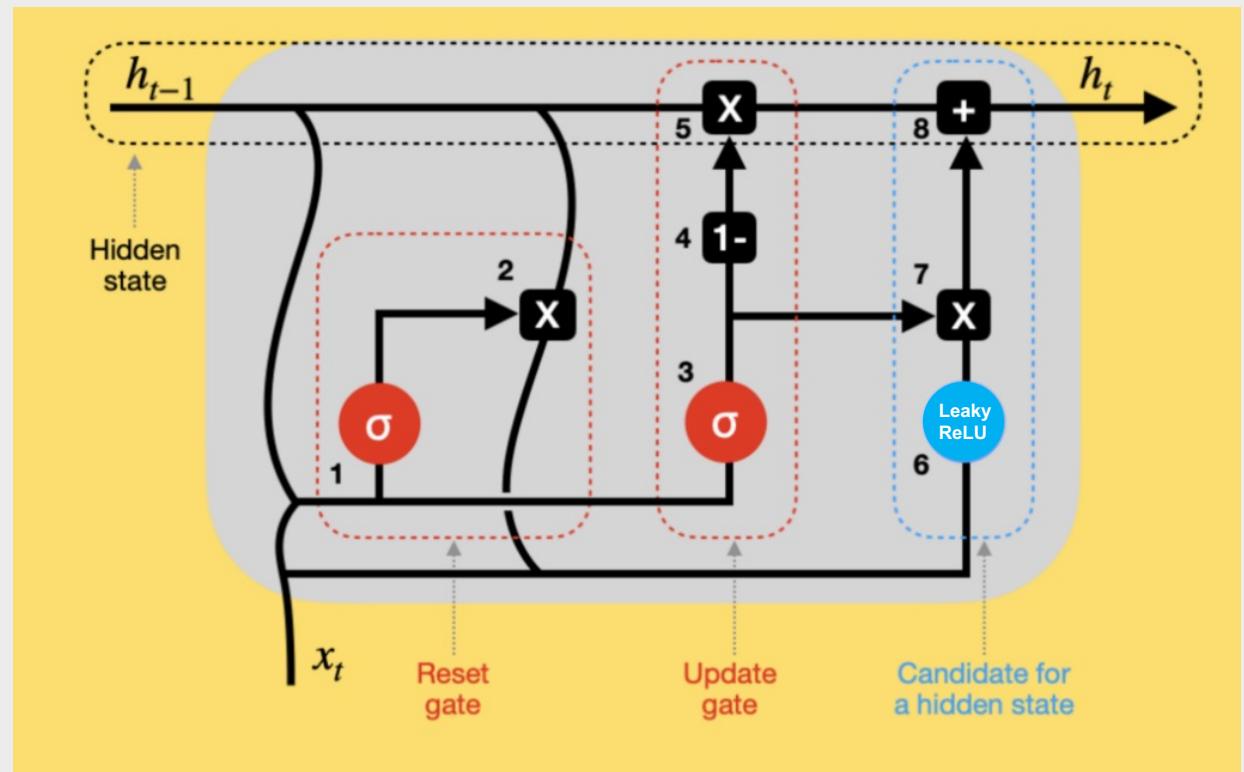
GRU Autoregression Forecasting Model

- Models evaluated with Mean Absolute Error (MAE).

Mean Absolute Error (MAE) of Best Model

	IP Semi-Conductor	ICAP Semi-Conductor	ICAP Motor Vehicle
USA	0.29	0.16	0.08
KOR	0.38	0.20	0.56

Gated Recurrent Units (GRU)
Neural Network



Introducing SCDash

(Semiconductor Diagnostic
Accelerator & Supply-Chain Hub)

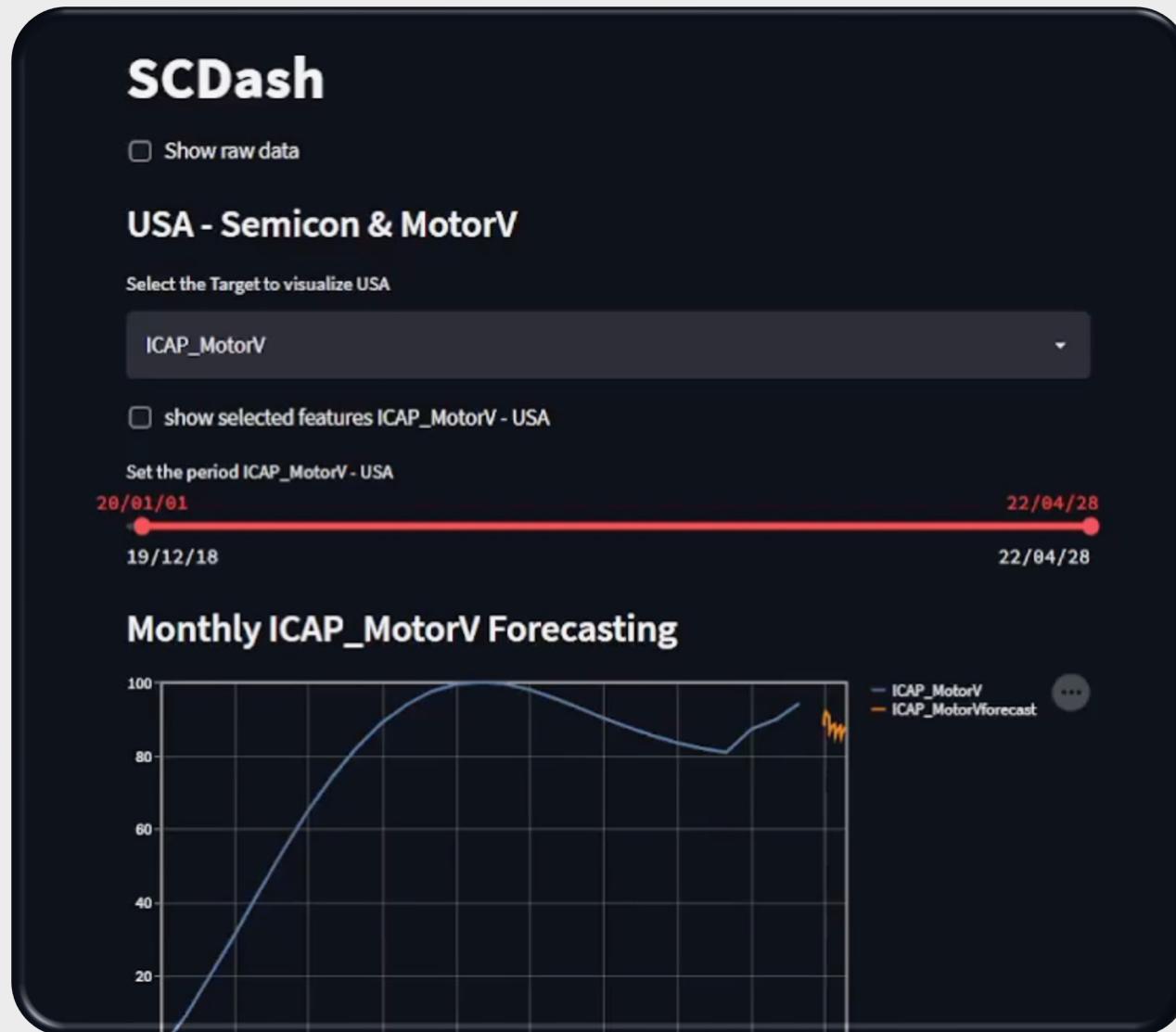
- Dashboard & Datahub
- Forecasts COVID-19 affects on manufacturing production
- Automatically updates monthly production data across suppliers

Data Synced through API

Private Company and Government Partnership

Collaboration between U.S. and South Korea

Prototype and Interface



Forecast Up to 28 Days into the Future

Web-based Dashboard

- Real-Time Data
- Trends Over Time
- Alerts for production and manufacturing capacity

Importance and Benefits

End Users:

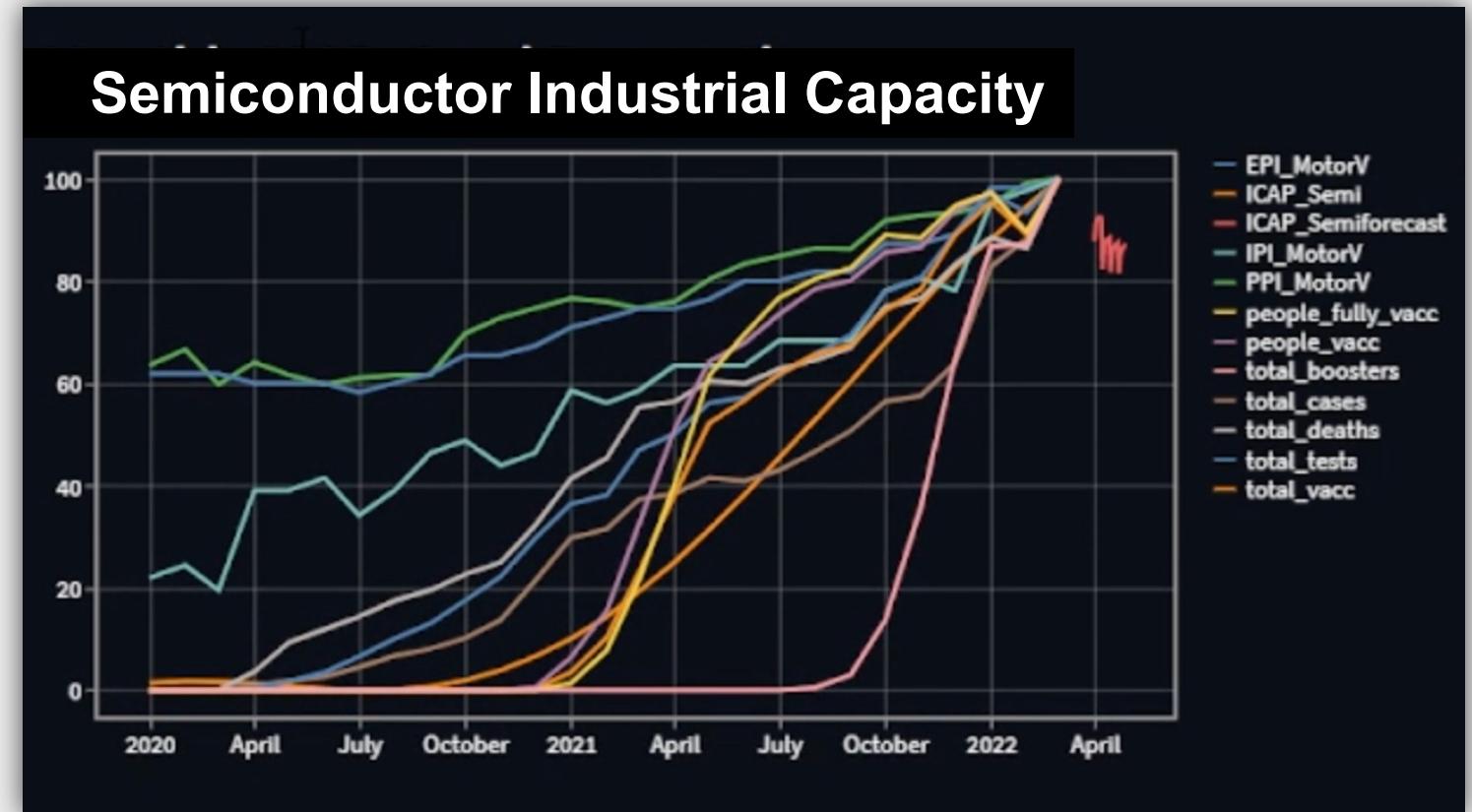
- Manufacturers
- Suppliers
- Governments

Planning and Logistics:

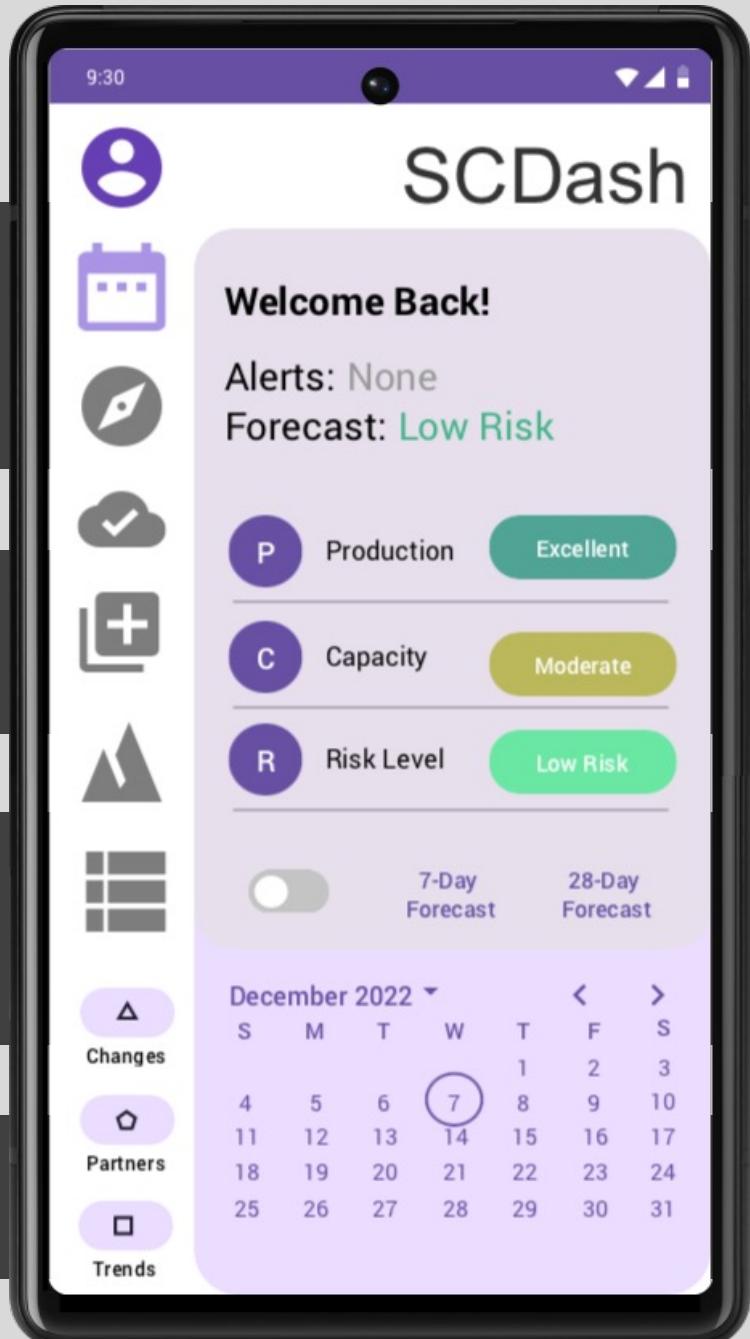
- Plan for Inventory
- Plan for Stockpile
- Better Business Strategies

Technology Partnership:

Government & Private Companies
Support for Small Businesses



Conclusion



Key Factors for Semiconductor Production and Capacity:

- United States: Vaccinations
- South Korea: Testing, Vaccinations

Key Factors for Motor Vehicle Manufacturing Capacity:

- Both Countries: Production and Capacity of Semiconductors

Policy Recommendations:

- Advocacy for vaccinations and continued funding for testing
- Financial support in semiconductor manufacturing

Technology Partnership:

- Government and Industry Investment in SCDash

Limitations

Workforce Data Not Considered in Model

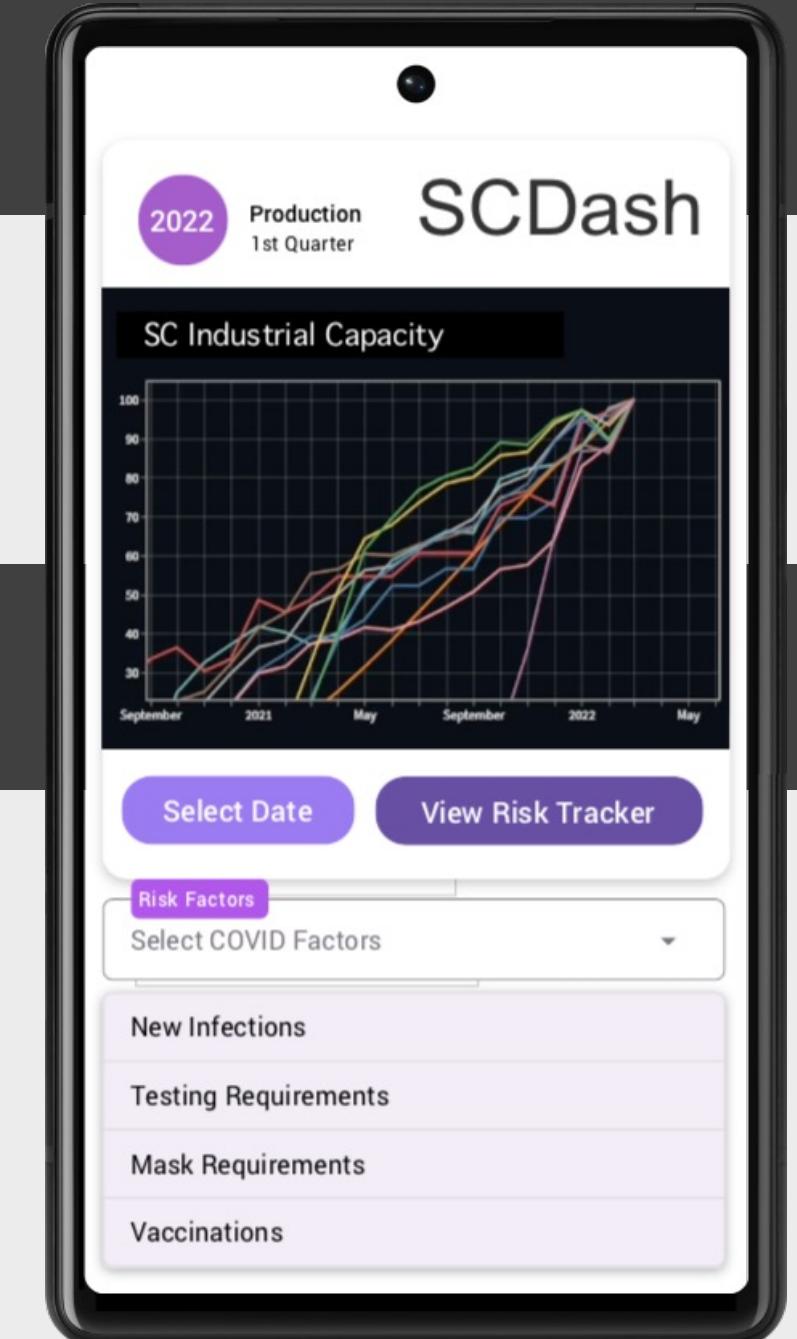
Time-Series Methods not applied for Regression

Future

Expand models to predict more industries

Enhance Forecasting to all regions and countries

Develop SCDash to mobile application for wide-scale adoption and use.



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