

Market Dynamics and Economic Analysis in the Tech Industry: A Study of GPU Demand Growth and Semiconductor Shortages

Links of the articles:

<https://www.forbes.com/sites/greatspeculations/2024/07/09/nvidia-stock-a-reality-check/>

<https://www.ijtsre.org/papers/2023/ev6c1/IJT-44712257.pdf>

Authors:

- Adrian Alvarez Sande - 15855619
 - Tiago - 15317323
-

Example 1: Analysis of NVIDIA's Growth and Demand Response for GPUs in the AI and Gaming Context

For the second quarter of 2024, the company NVIDIA posted quarterly revenues of **\$13.500 millions**, nearly doubling from **\$7.100 millions** in the same quarter in 2023. This is a **90%** increase that's driven by demand for AI solutions and the use of GPUs in a multitude of technology sectors such as gaming or multimedia.

Modeling Exponential Growth

Supposing that NVIDIA's revenue growth $I(t)$ as a function of time t follows an exponential function

$$I(t) = I_0 e^{kt} \quad \text{where:}$$

- I_0 is the initial revenue (for our analysis, **\$7.100 millions in 2023**),
- k is the growth rate,
- t is the time in years.

Calculation of the Growth Rate k

We use the data provided by the article:

- Income in 2023: $I(0) = 7,100$ millions USD
- Income in 2024: $I(1) = 13,500$ millions USD

We solve for k :

$$13,500 = 7,100 \cdot e^k \implies e^k \approx \frac{13,500}{7,100} \approx 1.9014$$

Therefore, the projected revenue function is:

$$I(t) = 7,100 \cdot e^{0.641t}$$

Interpretation of the first derivative:

The derivative of $I(t)$ with respect to time tells us the instantaneous growth rate of income:

$$I'(t) = 0.641 \cdot 7,100 \cdot e^{0.641t} = 0.641 \cdot I(t)$$

The first derivative of the income function provides information on the instantaneous growth rate at any instant in time of NVIDIA's revenue. In this case, the derivative is always going to be positive at any time, indicating a fast increase of revenue from NVIDIA. The main reason for this increase is due to the growing demand from sectors like AI and gaming.

For example, in 2024 ($t=1$), this growth rate is:

$$I'(1) \approx 0.641 \cdot 13,500 \approx 8,653.5 \text{ million USD/year}$$

Interpretation of the second derivative

The second derivative can be expressed:

$$I''(t) = (0.641)^2 \cdot I(t)$$

The 2nd derivative is also positive, confirming that the growth rate is not only positive, but also increasing, indicating an acceleration in demand for NVIDIA products, which is relevant in the context where the company is positioned as a leader in graphics processing for AI.

Projecting Future Growth Rates : Nvidia growth rate between 2023 and 2024 was 90%. Assuming that NVIDIA's growth rate decreases over time, we can set a growth of 50% between 2024

-2025 and 30% between 2025-2026 and then calculate future revenue projections for the company.

Revenue Projections

- 2025: $I(2) = 13,500 \times 1.5 = 20,250\text{M USD}$
- 2026: $I(3) = 20,250 \times 1.3 = 26,325\text{M USD}$

Example 2: Analyzing Semiconductor Shortages During COVID-19

Article Title: The COVID-19 Pandemic and Supply Chain Disruption: An Analysis of the Semiconductor Industry's Resilience

The article discusses the recent semiconductors shortages during the Covid-19 pandemic. The author highlights the tremendous impact Covid-19 had on both the production and the demand of semiconductors around the world. By using data from the article, we will analyze how the exponential growth of the demand in 2021 drowned the semiconductor market into a major crisis.

Short-Term Exponential Demand Model

The sudden shift in semiconductor demand during the COVID-19 pandemic can be represented with **an exponential growth** function. This model captures the rapid, **short-term** increase in demand as remote work, gaming, and digital consumption increased worldwide. The actual demand model, $D_{actual}(t)$, can be defined by the following equation:

$$D_{actual}(t) = D_0 e^{rt}$$

where:

- D_0 is the initial demand (assume this value represents the demand at the start of 2020).
- $r = 0.27$ is the growth rate, representing an annual increase of 27% in 2021 (according to the paper).

This exponential function is appropriate for short-term demand fluctuations in rapidly changing conditions. This model assumes that demand compounds continuously, reflecting the demand for semiconductors driven by both consumer electronics and enterprise infrastructure needs.

Forecasting Demand and Errors

To understand the gap between industry expectations and actual demand, we can define a forecasted demand model based on pre-COVID growth assumptions. For semiconductors,

industry forecasts before the pandemic anticipated a slower, more stable growth rate. In 2018, the semiconductor industry faced a 12% decline of the market, explaining why experts forecasted a 2% growth before Covid. The forecasted demand, $D_{forecast}$, is represented as:

$$D_{forecast}(t) = D_0(1 + r_{forecast})^t$$

where:

- D_0 remains the same initial demand as used in the actual demand model.
- $R_{forecast} = 0.02$ or 2%, is the annual growth rate forecasted by experts before the pandemic.

By comparing this forecasted demand with actual demand, we observe a forecast error, defined as:

$$E(t) = D_{actual} - D_{forecast} = D_0 e^{0.27t} - D_0(1 + r)^t$$

Calculating the Forecast Error After 1 Year

We can use this formula to understand how much the forecasted demand puts pressure on the semiconductors industry. To do this we will use arbitrary numbers for the initial demand as this is not data given in the article and it is a hard number to get. That being said, an arbitrary number enables us to illustrate the pressure the semiconductor industry faces after wrong forecasted demands were given.

Assuming an initial demand $D_0 = 100$ units:

- **Actual Demand after 1 Year:** $D_{actual}(1) = 100 \cdot e^{0.27} \simeq 131 \text{ units}$
- **Forecasted Demand after 1 Year:**
 $D_{forecast}(1) = 100 \cdot (1 + 0.02) = 102 \text{ units}$

The **forecast error** after 1 year is:

$$E(1) = 131 - 102 = 29 \text{ units}$$

This fictional example perfectly illustrates that actual demand exceeded forecasted demand by 29 units, indicating substantial unanticipated pressure on the semiconductor industry. It is important to note that these are not the only drivers of the shortage, as lack of supply, draughts and limitation in trade also played roles.

REFERENCES

1– [ANÁLISIS de NVIDIA \(ANTES de su PRESENTACIÓN DE BALANCES\)](#)

2–<https://www.forbes.com/sites/greatspeculations/2024/07/09/nvidia-stock-a-reality-check/>

3–<https://www.theguardian.com/technology/article/2024/aug/28/nvidia-nvda-q2-earnings-report>

4- Ochonogor, Kenechukwu Nwuka, et al. "The COVID-19 pandemic and supply chain disruption: an analysis of the semiconductor industry's resilience." *Int. J. Tech. Sci. Res. Eng.* 6.1 (2023): 7-18.