

**A Work Project, presented as part of the requirements for the Award
of a Master Degree in Economics / Finance / Management from the
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**Probably the most successful company
you've never heard of**
Producing the chips that connect us

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Abstract

This dissertation aims to provide an independent view of TSMC. This report covers a DCF and Multiples Valuation, and a Sensitivity and Scenario Analysis for TSMC. The global chip shortage has brought a big debate over the importance of semiconductors to the modern world and has shown that the rise in demand for chips is here to stay. TSMC is a major geopolitical actor, being assisted by several developed economies to respond the increase in demand. These are some of current and most important topics impacting the firm. Overall, TSMC has announced solid future perspectives which makes me optimistic about its future.

Keywords: Valuation, Semiconductor, Chips, Foundry, Wafer

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This report is part of the “Probably the most successful company you’ve never heard of – Producing the chips the connect us” and should be read has an integral part of it.

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Internet of Things

Internet of Things (IoT) is a concept which relates to any device that connects to the internet or other communication system, creating a network between these devices and their users. **IoT is empowered by 5G, artificial intelligence, and big data.** Nowadays, linking any device to the internet, is relevant to have information regarding its performance, to improve the technology, to study the people's interactions with the devices to create better and simpler products. The field has evolved due to the convergence of multiple technologies.

The need to have more devices connected is growing exponentially, according to Verified Market Research, and **revenues will grow by 26% every year until 2026.** Moreover, after that year we assumed it will grow at the world's GDP growth rate, around 2.70%. The reason for this assumption is IoT is being a relevant driver of the economy's increase, and that it will be seen "everywhere" in our personal and professional lives. Therefore, **IoT market size is expected to grow from \$420.9 billion in 2021 to \$1 471.2 billion in 2030. (Exhibit 19)**

The next steps that explain the development of this platform are related to wearables, which monitor users' preferences and habits; smart home devices that learn user's habits to develop automated home support for everyday tasks; smart city; and smart industry.

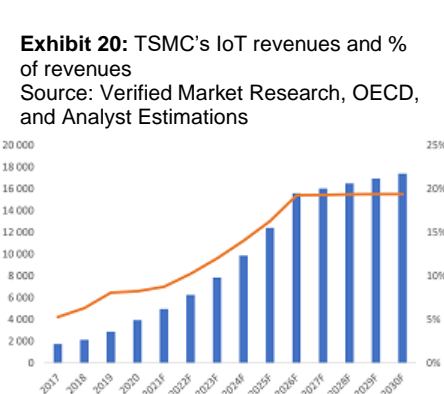
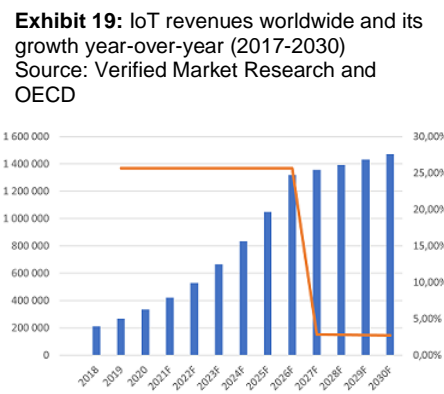
Nevertheless, **there are some risks regarding security and privacy**, which increase the governments' concerns to improve international agreements and guidelines to protect the users.

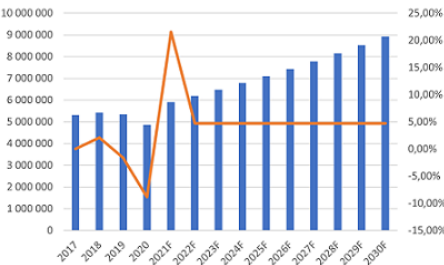
TSMC provides integrated ultra-low power technology platforms to enable innovations for artificial intelligence of things applications. The company had a share of 5% on revenues for IoT in 2017 and now has 9%. **We expect to be the one with the highest growth on percentage of revenues until 2030** due to the evolution of the platform. (Exhibit 20)

Automotive

Exhibit 21: Automotive revenues worldwide and its growth year-over-year (2017-2030)
Source: Statista, Scotiabank, and Analyst Estimations

Exhibit 19: IoT revenues worldwide and its growth year-over-year (2017-2030)
Source: Verified Market Research and OECD





The automotive market is expected to have a revenue of \$8 931 billion in 2030 compared to \$5 315 billion in 2017, according to Statista. It benefits from data-connectivity services since consumers will be constantly aware of technological advances, which will further increase demand for upgradability in privately used cars as well. **(Exhibit 21)**

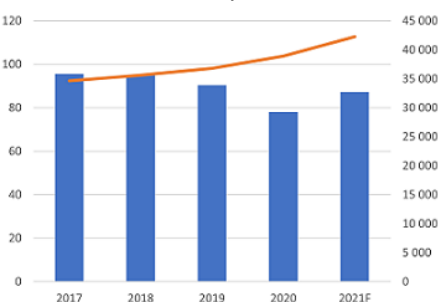
Moreover, a McKinsey paper complements this forecast, accordingly, **global car sales should continue to grow, but at a lower annual growth rate.** This drop will be largely driven by macroeconomic factors and the rise of new mobility services such as car-sharing and e-hailing. **Also, when technological and regulatory problems are resolved, fully automated cars will be able to circulate, which will value the semiconductor market through the increase of chips demand.**

To analyse the automotive market size, we can consider two drivers, such as **price and sales.** With the pandemic, the shortage of semiconductors stems, when automakers around the world closed factories and suddenly cut their orders for chips. At the same time, manufacturers of other electronic devices were demanding more chips as sales of their products boosted. Semiconductor producers allocated the production to this demand. As referred previously, when automakers resumed production, chipmakers had much less production capacity to assign for automotive chips. Interestingly, we see a crisis on the supply side, which is not able to respond to the consumers' desires. Hence, **sales decrease, which led companies to increase prices for these products.**

Some car manufacturers executives announced that they expect the silicon concern to remain, due to several problems. One is the persistent lockdowns in Asia countries, where there is a big share of the automotive production, which is slowing car producers' orders of chips. Another is the exponential growth of the IoT market, which is harming other platforms' production since there is not sufficient silicon material to respond to the demand in all platforms. Therefore, automotive, and other markets are more concerned with the future since they are highly dependent on the semiconductor segment.

Due to the pandemic, we expect the **average price of new cars to increase from \$38 920 in 2020 to \$42 258 in 2021.** Hence, giving a **growth rate of 22% in the market size in this period,** since car production also increases. **(Exhibit 22)**

Exhibit 22: Automotive average price and Car Sales
Source: Statista, Kelley Blue Book



According to TSMC 2020 annual report, “Automotive Electronics Platform provides a comprehensive spectrum of technologies and services to support the three megatrends – safer, smarter, and greener – in the automotive industry”. Moreover, “it is an industry leader in providing a robust automotive intellectual property ecosystem for advanced driver-assistance systems and advanced in-vehicle infotainment, the two most computationally demanding systems in the automotive industry.”

The company has a lower percentage of revenues on the automotive platform. Before the pandemic, it grew from 4% to 5% but has been decreasing since 2019. We expect the same trend until 2030, with values around 3.5% of revenues. This can be explained by the previous concerns described. Furthermore, TSMC’s revenues on automotive decreased during the pandemic. (Exhibit 23)

Exhibit 23: TSMC's Automotive revenues and % of revenues
Source: Statista, Scotiabank, and Analyst Estimations



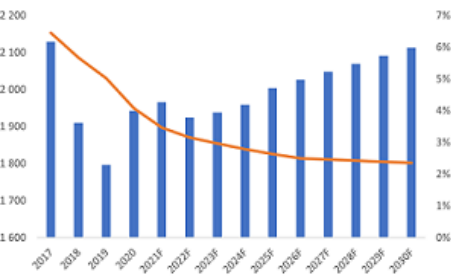
Digital Consumer Electronics

Digital Consumer Electronics (DCE) comprises two segments. **1) Electronic devices**, which are equipment intended for everyday use, typically in a private home, such as washing machines or refrigerators. **2) Digital devices**, which are also used privately but either for entertainment (television sets, radios, smart speakers, etc.), communication (telephones, smartphones, etc.), or home-office activities (printers, copiers). Like most digital markets DCE is **driven by innovation**, with a **constant improvement on existing products**. Therefore, many devices in this market have multiple purposes (e.g., smartphones can be used as cameras, radios, etc.). Some of the highest revenue brands in this category are Samsung, Dell, HP, Apple, LG, Sony, to name a few. DCE has two major markets: the US and China, which are also TSMC’s biggest sources of revenue.

Due to the covid pandemic, **expectations were exceeded, probably thanks to the “stay at home economy”**. According to Statista, **in terms of market size, DCE grew from \$494.4 billion to \$582.7 billion, in 2017 and 2021, respectively. Market Value is expected to be \$594 billion in 2025.** After, we simply assumed DCE would increase according to the growth of the population older than 14 years, around 1%, since they are the consumers of these devices.

DCE market benefited from the “stay at home economy”...

Exhibit 24: TSMC's DCE revenues and % of revenues
 Source: Statista and Analyst Estimations



TSMC offers customers leading technologies to deliver AI-enabled smart devices with DCE applications. **In its historical years, TSMC has had a decreasing trend in the weight of DCE, in % of its revenues, with 6.46% to 3.46%, in the years 2017 to 2021, respectively.** Although the weight has decreased, revenues have increased, meaning TSMC effort in the DCE was not able to keep up with the strong growth of its overall net revenues. With our calculations, we forecasted that % of revenues will keep decreasing to levels near 2%. The reason is the lower demand for this market compared to other platforms, so TSMC can shift their production to more interesting platforms. **(Exhibit 24)**

Finally, the revenues' forecasts are built on the assumption **that each platform's market demand will increase constrained by the chip's shortage.** The projections we made are that **TSMC will be able to respond to this demand with the increase in production.** Also, the fabs can shift production by platform, since production starts with an order of sale. Hence, the company platforms will grow as the platforms market growth. **This distinguishes among other investors,** who are more conservative on the power of TSMC response to the chip's shortage. To summarize the company's revenues by platform, we have for **Smartphone between 2021 and 20130 a CAGR growth of 2.31%**, rising from \$24 849 million to \$30 513 million. Also, **for HPC a CAGR growth of 5.60%**, increasing from \$21 018 million to \$34 325 million. Additionally, **for IoT, which had the highest CAGR of the platforms, with a value of 14.93%**. The platform went from \$4 978 million in 2021 to \$17 410 million in 2030. Regarding **automotive, we forecasted a CAGR of 4.70%**, increasing from \$2 271 million in 2021 to \$3 433 million in 2030. Finally, **for DCE we achieved a CAGR of 0.81%**, increasing from \$1 966 million in 2021 to \$2 113 million in 2030.

Financials

The Valuation is based on a DCF approach; hence we require to calculate the cash flows. To get the unlevered cash flow, we used the revenues described above, the core costs, the Capex, the Net Working Capital and the other changes on the non-current assets and liabilities.

Therefore, we breakdown the Financials' part into four segments. **1) Expenses. 2) Net Working Capital (NWC). 3) Invested Capital. 4) Ratio Analysis.** In the first one, we explain the costs associated with the company operating activity and provide a forecast for each account. In the second segment, we break down the main accounts relative to NWC and come up with a forecast. In the third one, we refer to the next investments and give a forecast for the Capex. Regarding the

last segment, we consider writing an extra analyse, which refers to a comparison with TSMC's peers regarding some ratios. Notice that this part is out of the scope of the DCF valuation but is important to understand how the company situates in relation with its competition.

Expenses

TSMC is a mature company, which shows to be solid and financially disciplined. **During up and down periods, gross profit remains at a stable level of around 50%. Its cost structure is well balanced, and highly connected to revenues.**

Depreciation and Amortization are included in the cost of revenue, being also a stable account around 27% and 1%, respectively. Research and development have been an area of strong importance for TSMC, with product and production efficiency innovation, with **a steady account of 8.3% of revenues. We expect it to continue with these constant levels since managers make relevant importance to spend firm values as a percentage of revenues.** General and Administrative expenses are expected to grow in line with **employees' average cost, with an average value of \$16 000 from 2017 to 2021, growing with inflation.**

Aligned with these expenses, **operating income has been around 34.88% and 42.27%, since 2017 and 2021.** We expected them to be approximately 39% over the next years, showing the costs' risks the company faces.

Net Working Capital

Usually, TSMC has a positive Net Working Capital (NWC), **showing a good operational efficiency. We can see that from 2017 to 2018, with a growing NWC, changing by \$1 838 million.** Nevertheless, the value is not substantially positive and even in 2019 and 2020 is negative, **which shows a possible concern on paying back to creditors.** In fact, accounts payable have increased significantly. Also, inventories have decreased, possibly due to the lack of demand before the pandemic.

Concerning the company financial decisions, **we assumed 10% of cash to be operating cash.** The reason is TSMC does not need much to meet its obligations, as it **has stable liabilities and almost no debt.** Also, it **almost only invests with its cash,** hence the big majority goes to excess of cash.

Regarding **an activity perspective,** production companies, which have factories and inventories, can be analysed with the **cash conversion cycle.** To calculate it,

TSMC has stable liabilities and almost no debt...

we have the **collection period** representing the number of days the company needs to wait on average, to receive cash from its sales. The **payable period** is the number of days the company, on average, pays the cash from its expenses. The **holding period** is the number of days the company, on average, keeps the inventory in the warehouse. TSMC has a **collection period** of around 45, a **payable period** around 60 before the pandemic and above 100 after, which shows a great power from the company to negotiate their contracts and to pay later, and a **holding period** from 52 to 80, since 2017 to 2020. This gives a **positive cash conversion cycle** from 2017 to 2018 decreasing from 2019 to negative or almost negative values, which shows the bargaining power of the company to collect the cash before paying it. **In order to forecast inventories, accounts receivable and accounts payable, we used these ratios.**

In the end, we predict that the company **NWC will be positive, with an increase of around \$200 thousand every year until 2030.** The reason is due to the investments opportunity and the capability of negotiating their liabilities.

Invested Capital

The cash decisions go in line with the company's prospects, like the **\$100 billion investment in capital over three years.** This project has several implications/goals: **1)** Respond to the global chip shortage, as stated throughout the report. **2)** Lower global dependence on Taiwan, China, and South Korea semiconductor production. **3)** Allow TSMC to lead its peers in tech development. **4)** Follow new tendencies as we are entering a period of higher growth as the multiyear megatrends of 5G, and high-performance computing are expected to fuel strong demand for semiconductor technologies in the next years. Some examples of fabs that are an output of this plan are the **Arizona fab**, which represented a \$12bn investment, **fab 18, and fab 20, in Taiwan.** These latter ones will start production of 3nm and 2nm chips, respectively, which puts TSMC in an elite group of chip development.

Out of the scope of the \$100bn investment and drilling down the second point of semiconductor dependence on Asia-Pacific, TSMC Corporate has already announced a \$7bn expense on Japan's new subsidiary. **This investment will be largely supported by the Japanese Government, paying \$5.2bn.** Morris Chang, TSMC former CEO, has warned that **this expansion overseas would represent very high long-term costs,** especially compared to building the same

Japanese government is expected to offer multiyear support...

fabs in Taiwan. This could **put in cause the historical gross margin of around 50%**.

For the remaining years, we considered that the expenditures on capital should increase according to the worldwide semiconductor (including foundry) revenues. The reason is to adjust supply with demand, in order to respond to new global tendencies.

Quantitatively, **these investments translate in a capex increase per year of around \$28bn from 2021 to 2023**, to implement the \$100bn plan. After that, **we expect a downturn in 2024**, as we do not foresee any new projects so far and semiconductor revenues will not increase as latest years, since supply is going to adjust to demand. Nevertheless, **after 2025 we expect that demand will increase at its normal pace and capex investments will go around \$27 billion once more**, in order to adjust for demand.

Ratio Analysis

To analyse the company liquidity situation, we can perform some simple ratios. The **current ratio** is good to see how many current assets the company must have to meet its current obligations. TSMC's levels decrease from values higher than 2 to values lower than 2, due to the pandemic since the company might increase its current obligations to maintain a stable financial activity. The **quick ratio** takes out inventories, which are less liquid and, in this case, does not have a big impact in the analysis. The **cash ratio** is important for companies from the industry sector that are cyclical, which is the case for TSMC. It is important to maintain levels above 1 to preserve steady financial levels. TSMC has accomplished it over the years, even during the pandemic. It is important not to have a huge value above 1, since cash could be used to invest in new opportunities. Also, too much cash around loosens managerial discipline. Normally, the company is known for its cash investments, so, this value is around 1 and 2.

Moreover, we can use the ratios to compare TSMC with the rest top 5 companies with more revenues. **Regarding a Cash Flow Management perspective**, we can analyse the Activity Ratios. Before the COVID-19, **TSMC is the one that maintains the best bargaining power**, with the lowest cash conversion cycle, without considering Global Foundries. **(Exhibit 25)**

On a Short-Term perspective, the Financial Ratios are good to analyse the company's liquidity. It is important to notice that the sector is very cyclical, and companies make large cash investments, almost without debt. Hence, it is normal that companies have different ratios over the years. **According to the average of**

historical years, TSMC's cash ratio goes aligned with the other peers. Only, the most recent IPO Global Foundries, which must increase its obligations more than the others to follow the competition, has an alarming cash ratio. **(Exhibit 26)**

On a Medium-Term perspective, the solvency ratio focuses on figuring out whether the firm has a sustainable amount of leverage (and resulting capital structure) to finance its activity. **Clearly, the industry has solvency ratios very high, due to the reduced debt. These very high ratios allow companies to leverage in good investments if they need.** The financial autonomy ratio is very similar for each company, **showing once more the industry independence towards their creditors. (Exhibit 27)**

Interestingly, Global Foundries has a capital structure well defined even though their liquidity situation is dangerous. This shows a consolidate company making investments expecting to reach the competition. **This demonstrates the power of the industry, which lets smaller companies with good capital structures to gain power.** Whenever a company sees an opportunity, it can easily take it. Nevertheless, the same applies to TSMC, which already has stability and a well capital structure, which does not depend much on creditors.

Exhibit 25: Peer analysis of Activity Ratios, 2019

Activity Ratios	TSMC	UMC	SMIC	GlobalFoundries	Towerjazz
Collection Period	47,70	65,45	56,82	0,00	37,55
Holding Period	52,47	101,10	132,99	20,24	69,87
Payable Period	114,45	100,09	189,15	76,70	43,32
Cash Conversion Cycle	-14,29	66,46	0,66	-56,45	64,11

Exhibit 26: Peer analysis of the average historical years Liquidity Ratios

Average historical years	TSMC	UMC	SMIC	GlobalFoundries	Towerjazz
Current Ratio	2,09	2,16	2,59	1,54	4,02
Quick Ratio	1,88	1,87	2,36	1,22	3,32
Cash Ratio	1,27	1,29	1,30	0,45	1,39

Exhibit 27: Peer analysis of Capital Structure Ratios, 2019

Capital Structure Ratios	TSMC	UMC	SMIC	GlobalFoundries	Towerjazz
Financial Autonomy Ratio	71,28	55,98	62,04	62,21	69,68
Solvency Ratio	248,24	127,15	163,43	164,63	229,77

Valuation

We valued TSMC using a DCF approach, as we believe that it captures the value that shareholders will derive from this stock. This approach allows us to include major assumptions and future expectations about the business and allows us to build scenarios and sensitivity analysis. Additionally, we used a Multiples approach as we believe that it is a good complement to DCF.

For our valuation we used a forecasting period of 9 years from 2022 to 2030. We computed the DCF with a **WACC of 5.03%**, which we used to discount all future cash flows, and a **terminal value growth rate of 2.47%**.

We are aware that the DCF approach is very sensitive to changes in assumptions and may be prone to overcomplexity and to errors. For this reason, we included five scenarios in our analysis. One main case, which is the most probable and is under the name "Our case". Two more optimistic "Bull cases", one with a downturn and the other with no experience of downturn. Finally, two more negative "Bear cases", also one with a downturn and the other with no experience of downturn.

Our model resulted in a weighted-average **share price of \$162.22**, which yields a **total return of 39.80% compared to the price of \$116.04, as of December 14th, 2021**. Therefore, we give a **BUY recommendation**.

DCF Valuation

In order to compute the DCF, we separated into four parts. **1) Unlevered Cash Flows, 2) Discount Rate, 3) Non-Core Result, and 4) Financial Debt**. With these we can calculate the Enterprise Value.

▪ Unlevered Cash Flows

As described on the financials, to get the unlevered cash flow, we used the revenues, the core expenses, the capex, the net working capital and the other changes on the non-current assets and liabilities.

Hence, we have an unlevered cash flow for 2022, with a value of \$6 438 million. This value is similar to the previous years. The reason is the amount of capital expenditure related to the new projects. Even though in 2023, we face the \$100 billion investment in capital, **we expect the unlevered cash flow to double, since we can already observe the impact on revenues**. In 2024, we have a boost in the unlevered cash flow, with a value of \$40 892. The reason is that **capex should lower its pace and revenues increase even more** due to the increase in production.

After 2024, the unlevered cash flow is around \$25 000 million. The main explanation is the good response TSMC is giving to the increase in demand. Therefore, almost all production the company is going to have, will be sold.

Regarding Capex and NWC, the company will maintain adjusting its investments to respond to the increase in demand.

▪ Discount Rate

To estimate TSMC's **cost of debt, 2.20%**, we picked a bond maturing in 2031 from Bloomberg, with a Yield to Maturity (YTM) of, 2.27%. **According to Moody's the group's credit rating is Aa3**, which gives a 5-year probability of default of 1.20% and a corresponding recovery rate of 53.90%.

Furthermore, to calculate TSMC's **cost of equity levered, 5.14%**, we computed the Capital Asset Pricing Model (CAPM). Hence, we computed its betas, **used an expected market return of 5%, according to JP Morgan**, and a **risk-free rate of 0.91%**, which is the Market Yield of US Treasury Securities, from Federal Reserve Economic Data (Fred) as of December 2020. Once we determined all these variables, we reached a **WACC (Corporate Tax) of 5.03%**.

To get the beta levered, we regressed TSMC's stock returns, using data from the last 5 years. Monthly returns were used to avoid biases related to shorter periods of time. The market proxy used in the regression was the iShares MSCI World ETF (URTH). The reason is that the company is predominant in the world economy and its decisions affect every country. In order to get a forward-looking beta, we adjusted it according to Bloomberg method, achieving a beta of 1. The result is quite acceptable since **the company is a world economy engine**. Hence, we expect the company's returns to change accordingly with the market. Nonetheless, to reduce the idiosyncratic risk we used TSMC's peer companies to estimate the raw beta (5 year, monthly). With this we achieved **an industry beta unlevered of 1.01**. As the company has low debt, the beta levered is close to the unlevered one, with a value of 1.03. **The value is almost the same as the company's own regression, which shows that competition has similar returns. Once more, this is a plausible behaviour due to the impact semiconductors have on the world economy.**

Concerning, expected market return, **we investigated a JP Morgan study of 2022**. It provides several expected equities returns for specific regions of the world. **We decided to consider their global perspective, with a value of 5%**, despite the significant fall from the pandemic. According to the study, equity markets can sustain equilibrium P/E ratios (and margins) that are higher than they were in the

Exhibit 28: WACC Estimation
Source: Bloomberg, TSMC Annual Report, Yahoo Finance, Moody's, and Analyst Estimation

Risk-Free	0,91%
Expected Market Return	5,00%
Market Risk Premium	4,09%
Beta Unlevered	1,01
Beta Levered	1,03
Cost of equity levered (Re)	5,14%
Cost of debt (Rd)	2,20%
Corporate Tax Rate	20,32%
D/EV	3,23%
E/EV	96,77%
WACC	5,05%
WACC corporate tax	5,03%

past. **The reasons are** equity markets have become less exposed to cyclical sectors. This reduces the volatility of earnings, which may lead investors to pay a higher premium for those earnings. **Also, due to the pandemic, companies' valuations have decreased, which will result in stronger earnings growth.** As the studied company affects and is affected by the entire world, we considered the global expected equities returns as a good proxy to our beliefs on what we reckon an investor would expect from the market. Hence, also using the risk-free rate of 0.91%, we considered a market risk premium of 4.09%. Nevertheless, we know this is a very sensitive variable, hence we performed a sensitivity analysis.

Moreover, from the annual report we used **a corporate tax of 20.32% from 2020**, which is the most recent and accurate value. Also, **a debt of \$20 593 million and a market cap of \$601 783 million**, computed from the **stock share price of \$116.04 as of December 14th, 2021**, and **5 186 million outstanding shares**.

Our growth rate, 2.47%, was computed by calculating the return on new invested capital (RONIC) with the reinvestment rate (RR). The RONIC was calculated with a 2-year lag, since it takes around 2 years to start producing after the beginning of the fab construction.

We are aware that the growth rate is an important variable to consider, since it will determine how the company will perform in perpetuity. Thus, to avoid presenting a terminal value when the company is still going through major changes, we assumed a growth rate of when ROIC was not growing, for instance from 2028 to 2030, with a value around 30%.

▪ **Final DCF Remarks**

The **sum of discounted cash flows and terminal value were \$144 089 and \$698 623 millions, respectively.** Regarding **Non-Core Result**, we assumed the book value, as the cash flows come from sources other than its “day-to-day” operations. Therefore, **the value in 2022 is \$7 547 million.** Also, **Net Financial Debt** was computed with the book value method, since the company operates with almost no debt. Hence, **Net Financial Debt is -\$8 974 million.**

To conclude, we achieved an Enterprise Value of \$841 285 million.

Multiples Valuation

Exhibit 29: DCF Key Stats
Source: Analyst Estimations

Sum of discounted cash flows	144 089
Terminal Value	698 623
Non Core Result	7 547
Debt	-8 974
Value of Equity	841 285

Exhibit 30: Multiples Valuation
Source: Bloomberg

	EV/EBITDA - 2022	P/E - 2022
TSMC	14,1x	29,7x
Applied Materials	12,7x	22,2x
Intel Corporation	6,7x	9,5x
VIS	10,9x	21,6x
Texas Instruments	17,2x	23,5x
UMC	6,0x	14,4x
Hua Hong Semi	12,0x	40,9x
Foxconn	5,6x	10,5x
Samsung Electronics	3,6x	11,5x
SMIS	12,9x	22,2x
TowerJazz	5,8x	23,9x
Average	9,8x	20,9x
Share Price	73,89	76,34
Average Share Price	75,11	

We are aware that a standard multiples valuation approach would give us an expected price for the end of 2021 and not for the end of 2022, which is our goal. So, we decided to add a forward multiple approach. We believe that **this valuation approach is a simple way to free ride on market's information**, since what investors care about is what the market is willing to pay. The main idea is to value TSMC using information on the pricing of similar companies. While choosing comparable firms, we considered that we would face a bias-variance trade off. Too many firms would mean that some of them are not truly being comparable and too few firms would mean that our multiple would reflect idiosyncrasies of those firms. For these reasons we based our selection of these comparable companies on whether they had a **foundry business model** or not.

We were able to identify 10 companies that serve as comparable. We used the EV/EBITDA and the trailing adjusted P/E ratios to make this valuation. Although the P/E ratio is the most popular and widely used, it has inherent flaws for which the EV/EBITDA ratio compensates. We reached an **average share price of \$75.11**, which is far from our target price and reinforces the idea that **our valuation distinguishes from some investors**.

In fact, it is worthy of mention that **this comparable multiple analysis, indicates that TSMC is overvalued compared to its peers**. Some investors might irrationally trust this valuation method and consider the actual price too high. Considering the industry risks and supply concerns, one might agree with this valuation. Certain factors like the investment in capital have a lag in their return on the investment as it takes usually 1 or 2 years to build the factories and start sales. This might be one of the reasons for the lower valuation. Moreover, the huge competitiveness existing on the industry can indicate that companies will converge on the long run. Nevertheless, there are several points that show the company can depart from its peers. First, it is important to consider **the influence this company has and the impact it has on the world**. For example, the support TSMC is receiving from Governments to expand production. **Second, the secrecy wherein the company operates**, which allows the company's products and way of producing to be unique. **Finally, the boost on demands the industry is facing, which can only increase the company's valuation if it has financial and management conditions to avail**.

Major economies seem to expect a future growth of the company. We also believe in this growth, but it can only be determined with a DCF valuation to consider the proper risks.

Scenario Analysis

The Corporate Finance Institute defines scenario analysis as “a **process of examining and evaluating possible events that could take place in the future**”. **Our model is very dependent on our assumptions** and so it is prudent to explore different cases/scenarios.

We decided to analyse revenues' variation given some scenarios. Thus, we computed varying 2 main assumptions. **1) Supply assumption, with Bull and Bear Cases. 2) Demand assumption, with Downturn and no Downturn Cases.**

For the supply, we analysed the **company's main problem, which is the capacity to meet the demand**. The construction or improvement of fabs the company has already announced will only affect production in a few years, with a normal lag of 2 years, due to the time of constructing the factories. Hence, it is important to analyse what would happen to revenues if the company was able to produce earlier, Bull Case, or to produce later, Bear Case.

For the demand, we changed some assumptions from our previous demand analysis, in order to create a scenario with a demand downturn. For example, the Smartphone will grow until 2026 with at same rate, but after that, it **will grow at an average rate of 0.76%, instead of the previous rate of 2.14%**. The reason is that demand for smartphones should still grow but at a lower rate since the **refurbished market will gain more power**. Also, the **HPC will increase at a lower rate, due to a possible delay in software and cloud computing technology improvements**. Regarding, IoT, we analysed a more conservative analysis, from Statista, with a **CAGR growth of 14% until 2030, giving a market size of \$1 058.3 billion instead of \$1 472.2 billion in 2030**. Finally, on the Automotive market, the average price is an average of previous years, with a value of **\$40 452**, and the **CAGR between 2021 and 2030 is less than 1 percentage point, considering that the automotive sector is not able to adapt well to the chip shortage**.

▪ Our Case

In our opinion, this is the most likely scenario, and we gave it a probability of occurrence of 65%, so we assumed it to be our main case. In “Our Case” we assumed that, in 2022, the fab 18 (p1 to p3) can increase its capacity to 40 000 wafer per month (wpm) for each fab and starts producing more. Also, fab 18 (p4 to p6) starts production. Then, in 2023, fab 18 (p7) can start production with 30 000 wpm. In 2024, fab 21 in USA and the new fab in Japan start producing. In 2025,

fab 20, starts production with 2 nm entering the market and fab 21, increases capacity like fab 18.

▪ Bull Case

The “Bull Case”, in 2022, starts with the same scenario as “Our Case”, where fab 18 (p1 to p3) can increase its capacity. The difference in the “Bull Case” is that we predict, in this optimistic scenario, TSMC would start fab 18 (p4 to p7) production, with a total of 120 000wpm. Finally, in 2024 and 2025, we end with the same scenario as in “Our Case”.

▪ Bear Case

In the “Bear Case”, we assumed a scenario where **3nm will enter the market one year later**. Only in 2023 the fab 18 (p1 to p3) can increase its capacity and starts producing more. Also, fab 18 (p4 to p6) starts production. Also, we predicted future projects to delay one year as well. Fab 18 (p7) can start production, in 2024, with a total of 120 000wpm. Fab 21 in USA starts producing in 2025. Fab 20, starts production with 2 nm entering the market and fab 21, increases capacity like fab 18, in 2026.

▪ Final Scenario Analysis Remarks

To conclude the Scenario Analysis, we can observe that in **Exhibit 30** we have probabilities for each case that we attributed. The “Bull Case” with no downturn is a highly possible scenario due to the **need of increasing production capacity**. Hence, we assumed **20% probability** of happening. The “Bear Case” with no downturn is less probable, since not only the company but also Governments, like the US, **are making all possible efforts to increase the semiconductor production**. But a **10% probability** reflects the possibility of having delays and problems achieving the desired goals. The Downturn Scenarios are less probable, since a decrease in demand is not a representation of what is happening nowadays. Nevertheless, it is important to notice that **consumers are very sensitive to price and quantity changes**. Therefore, if companies increase prices too much, it is possible that demand adjusts to lower levels.

Finally, we computed an expected price given all probabilities and scenarios' revenues, which gave us a result of **\$173.09**. This value is **similar to our expectations and meets our BUY recommendation**.

Exhibit 31: Scenario Analysis

	Probability of Case	Downturn of the industry in 2023	3nm Production + Year of Entry	CAGR Revenues	Price
Company Bull Case with no Downturn	20%	No experience of downturn	Largescale Production in 2022	6,45%	244,39
Company Bull Case with Industry Downturn	3%	Downturn	Largescale Production in 2022	5,34%	171,02
Our Case	65%	No experience of downturn	Smallscale Production in 2022	5,21%	162,22
Company Bear Case with no Downturn	10%	No experience of downturn	Pushes out Production to 2023	4,11%	115,55
Company Bear Case with Industry Downturn	2%	Downturn	Pushes out Production to 2023	3,02%	90,45
	TRUE				173,09

Sensitivity Analysis

Exhibit 32: Ranges for Beta impacting the WACC

Ranges for Beta					
	Min	Our Case			Max
Rf	0,91%	0,91%	0,91%	0,91%	0,91%
MRP	4,09%	4,09%	4,09%	4,09%	4,09%
Beta	0,99	1,04	1,09	1,14	1,19
Re	4,96%	5,14%	5,37%	5,57%	5,78%
Rd	2,20%	2,20%	2,20%	2,20%	2,20%
E/(E+D)	96,69%	96,69%	96,69%	96,69%	96,69%
D/(E+D)	3,42%	3,42%	3,42%	3,42%	3,42%
Tax Rate	20%	20%	20%	20%	20%
WACC	4,86%	5,03%	5,25%	5,45%	5,65%

In our DCF approach the variables that we **were more uncertain of were the Market Risk Premium (MRP) and Beta (β)**. For this reason, we computed a sensitivity analysis of the impact that changing the MRP and β have on the WACC. Afterwards, we computed the sensitivity of the price relative to the WACC, impacted either by MRP or β , and to the terminal growth rate. Regarding the growth rate, we set a difference of 0.5% given its unpredictability.

Exhibit 33: Impact of Beta on Share Price

WACC	Growth rate		
	1,97%	2,47%	2,97%
4,86%	148,72	174,13	213,04
5,03%	140,20	162,22	194,94
5,25%	130,96	149,63	176,49
5,45%	123,59	139,81	162,59
5,65%	117,02	131,22	150,74

Analysing **Exhibits 32 and 33**, we used the beta that we got in "Our Case" as reference, 1.03. Our betas will vary from 0.99 to 1.19. This will impact the WACC, making it range between 4.86% and 5.65%. Our β is higher than 1, meaning that the security's price tends to be more volatile than the market. We can observe that **an upside variation of β has a negative impact on the share price**, however in almost all situations it wouldn't change the final recommendation. Beta's sensitivity would make the share price range between \$117.02 and \$213.04. Overall, by looking at the results we can conclude that most cases would remain in a BUY recommendation, not changing from our case, which makes us confident about our valuation. Even at the lowest price we don't have a very significant variation from our target price (-38.63%), but this would change to a HOLD recommendation. Also, compared to the price of December 14th it would be a very small variation of 0.84% which would change our recommendation from BUY to HOLD.

Exhibit 34: Ranges for Market Risk Premium impacting the WACC

Ranges for MRP					
	Min	Our Case			Max
Rf	0,91%	0,91%	0,91%	0,91%	0,91%
Beta	1,04	1,04	1,04	1,04	1,04
MRP	3,60%	4,09%	4,60%	5,00%	5,50%
Re	4,64%	5,14%	5,68%	6,09%	6,61%
Rd	2,20%	2,20%	2,20%	2,20%	2,20%
E/(E+D)	96,69%	96,69%	96,69%	96,69%	96,69%
D/(E+D)	3,42%	3,42%	3,42%	3,42%	3,42%
Tax Rate	20%	20%	20%	20%	20%
WACC	4,55%	5,03%	5,55%	5,95%	6,45%

Analysing **Exhibits 34 and 35**, we used different MRP to cover various perspectives. For "Our Case" we used a study from JP Morgan that reached an expected market return of 5%, implying a MRP of 4.09%, giving our risk-free rate of 0.91%. We then varied 0.5 percentage points due to uncertainty of this variable.

Exhibit 35: Impact of Market Risk Premium on Share Price

WACC	Growth rate		
	1,97%	2,47%	2,97%
4,55%	166,37	199,73	254,30
5,03%	140,20	162,22	194,94
5,55%	120,17	135,33	156,37
5,95%	108,20	119,95	135,63
6,45%	96,25	105,07	116,42

We can observe that the share price varies between \$96.25 and \$254.30. The higher price shows a variation from our target price of 56.76%, which would not change our recommendation. The lower price, also not so far from our target (-40.67%) would make our recommendation change to SELL. Overall, most of the computed values would not change our position, which reinforces the idea that the **valuation is within a reasonable range**.

Recommendation

A DCF analysis allows to distinguish an investment from other alternatives, since it brings, among other information, detail about risks and opportunities the company in question will face. This detail is observed in our forecast of revenue, expenses, capital assets, changes in working capital, capital structure, cash-flows, terminal value, enterprise value, and equity value. With such level of detail, we reckon that we have comprehensively captured the intrinsic value of TSMC and all its future business expectations.

As our analysis showed, TSMC's future is dependent on variables like 3nm production and year of entry, semiconductor downturn, and growth of each platform. In our view, **TSMC has a vast potential upside**. The company has announced a massive \$100bn investment in capacity over 3 years. It is expanding overseas. However, **in our opinion, TSMC's growth is primarily driven by steady introductions of new tech nodes** that are largely unaffected by industry cyclicity and we expect this to remain a strong and lasting trend. The company is still one of the only 3 in the world that is capable of producing sub 10nm semiconductors; production of 3nm is expected to start in 2022, which will ensure tech leadership over its peers and work on 2nm chips has already started. TSMC has been able to generate revenue from its platforms and it should again succeed in the near future, in our opinion. We do point out, once again, that 3nm production is forecasted for the end of 2022. This means that the analysis may not capture all of TSMC's potential included in its plans since most announced investments still have a 1- or 2-year lag of return on investment due to building time of factories and other related factors.

Nevertheless, as a result of our analysis and valuation we obtained an **expected target price of \$162.22** and a **total shareholder's return of 39.80%**, comparing to the price on December 14th, 2021.

Therefore, our **recommendation is to BUY TSMC's shares. (Exhibit 36)**

Exhibit 36: Valuation Methods and Expected Price from Scenario Analysis

	APV	DCF	Expected Price from S.A.
Value of Equity	837 174	841 285	900 310
Price per Share (implied in US \$)	161,43	162,22	173,60
Return (%)	39,12%	39,80%	49,61%