UCD Michael Smurfit Graduate Business School

Yale SCHOOL OF MANAGEMENT

Semiconductor & Related Devices – SIC Code 3674

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INDUSTRY OVERVIEW:

Recommendation Date: 29th September 2021

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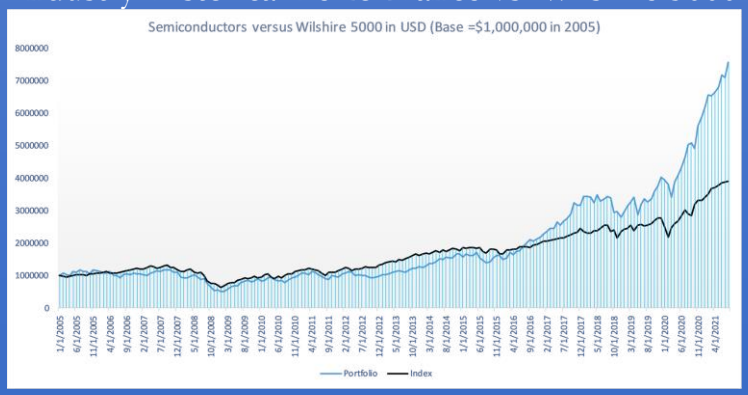
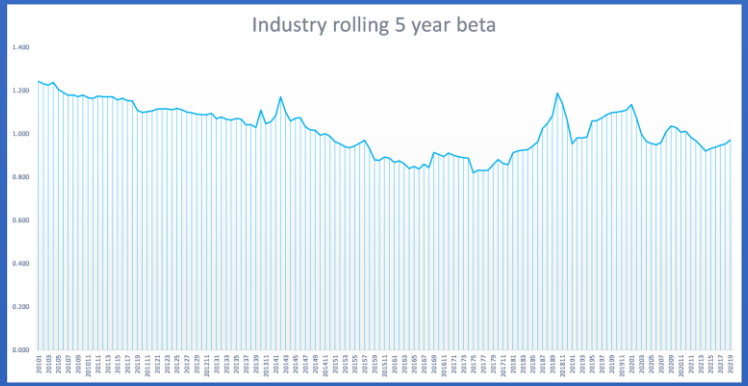
Industry Historical Performance vs. Wilshire 5000:



5 Year Rolling Beta:



RECOMMENDATION: SELL

Our recommendation for the Semiconductor & Related Devices industry is a sell. Whilst we hold strong conviction with regards to the future growth of the industry, we expect valuations to revert to more modest levels.

Revenue: CAGR 2022 – 2026 (12.02%)

The Semiconductor industry has and will experience further growth over the next 5 years due to the emergence of 5G technology, widespread adoption of electric vehicles, Internet of Things (IoT), and Data Centres.

Supply Shortages:

While supply issues remain prevalent across the globe, ASML has recently surpassed the 100th shipment of the extreme ultra-violet lithography (EUV) machines, of which all major semiconductor companies critically depend on. Coupled with TSMC's $100b capital expenditure plans and Intel's IDM 2.0 strategy, this build out of foundry capacity will soon meet current consumer demand.

Mixed Price/Earnings:

Across the industry, there has been a substantial uptick in overall price/earnings ratios. Intel has remained relatively level, but others such as Nvidia, Advanced Micro Devices, Infineon, and Microchip Technology are all selling at multiples in excess of 60x, more than double that of a market capitalization weighted portfolio of 14 semiconductor companies (29.97).

Valuation Summary:

Our estimates suggest an industry value of $2.037tn. This entails a sell recommendation with a downside risk of 9.46% versus the current market capitalisation of $2.25tn for the 15 largest semiconductor companies as of September 27th, 2021.

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Industry Overview

The semiconductor and related devices industry is well known for its pivotal role in the miniaturisation and facilitation of the growing demand for better and faster technology in every aspect of people's lives, both personally and professionally[1] The applications of semiconductors are widespread and range from day to day items such as mobile phones, personal computers, to the medical network in hospitals, advanced driver automation systems (ADAS), and bank ATMs[2] However, not all semiconductor companies are the same, and major differences are evident not only in the business model, but also in the types of products produced.

In the world of microelectronics, fabrication plants or "fabs", refers to the type of semiconductor plants where integrated circuits are manufactured. Other companies tend to focus on the design aspect of semiconductor devices and are thus deemed to be "fabless"[3]. Alternatively, a company that operates a fabrication plant to facilitate the deigns of other companies is considered to be a foundry. Intel is a full-service operator in the sense that they will design, manufacture, and sell their own products with over 15 wafer fabs in operation across 10 locations worldwide[4]. Other well-known companies like Nvidia and Advanced Micro Devices are examples of the fabless kind, outsourcing their manufacturing to foundries like TSMC and Samsung [5].

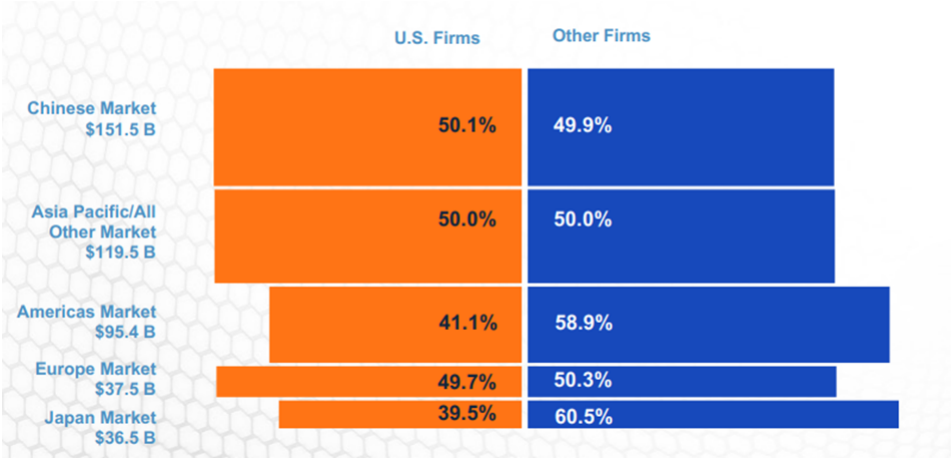
The next differentiator amongst semiconductor companies is through the types of products offered. Products like memories, logic, and other power electronics have widespread transferability, but other products are also manufactured for a specific purpose or a specific company.

Considering the split between business operations, and product segments, there remains the geographical aspect, which has become all the more important since the announcement of China's "Made in China 2025" strategy. The plan set out by the Chinese government is centred around the technology sector. The Chinese market is one of the largest in the world and is set to continue growing as a result of the increased funding, subsidies, and acquisition of intellectual property to "catch-up" with the western world in chip manufacturing[6].

The journey so far has not been without bumps in the road. In 2019 for instance, revenues fell by 3.7% as a result of the trade war between the United States and China, imposing strict tariffs on imports. Not only this, but large-scale conflict has also resulted in raw materials restriction between Japan and South Korea, specifically "fluorinated polyimide and resists, and about 70% of hydrogen fluoride"[7]

[1] (Businesswire, 2021)
[2] (Hitachi, 2021)
[3] (Alfalaval, 2021)
[4] (Intel, 2021)
[5] (Eassa, 2021)
[6] (McBride & Chatzky, 2019)
[7] (Lee, 2021)

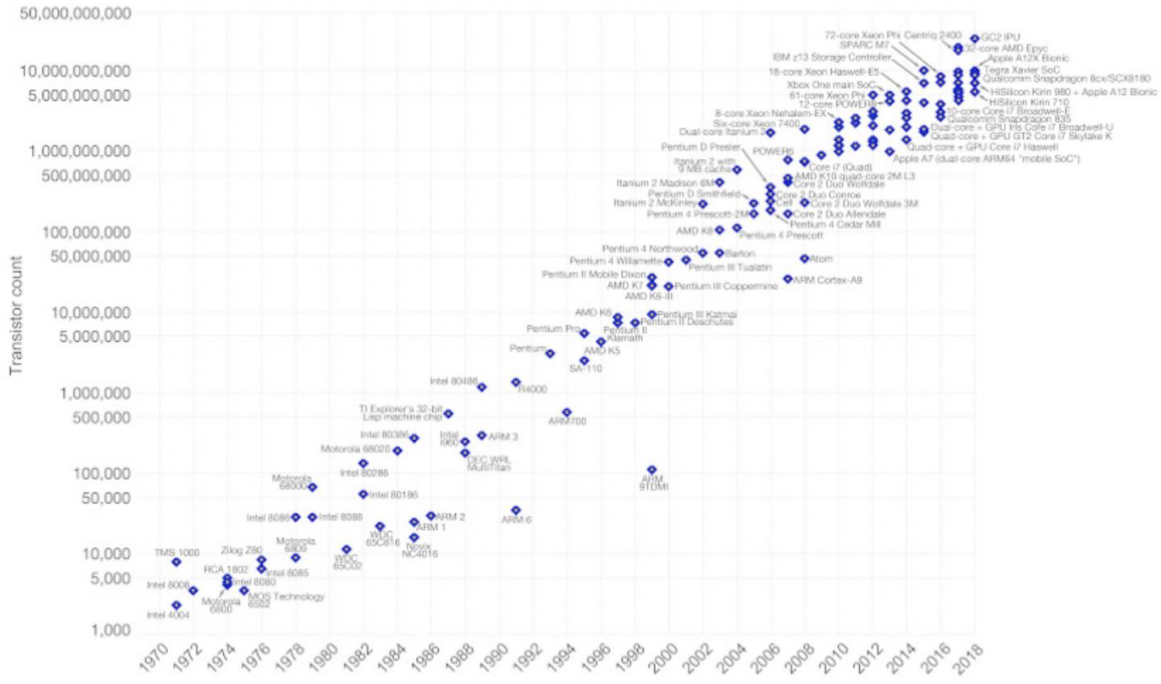
Figure 1:



Source: SIA Factbook[8]

Whilst the rollout of 5G was relatively muted in 2020, we are of the opinion that the adoption of 5G technology will mirror that of 4G except in a slightly higher order of magnitude. The exponential growth that was observed in 2020 is due in large part to the shift in the public's day to day. From online shopping and zoom calls, to university classes and business meetings, the demand levels observed has been pivotal in exacerbating today's shortage. This shortage is not only demand related but supply constrained. Moore's law is the term used to describe the rate of change in integrated circuits like transistors and capacitors – noting the doubling in the number of transistors being fitted to a chip each year[9] (Figure 2).

Figure 2: Transistor count per product

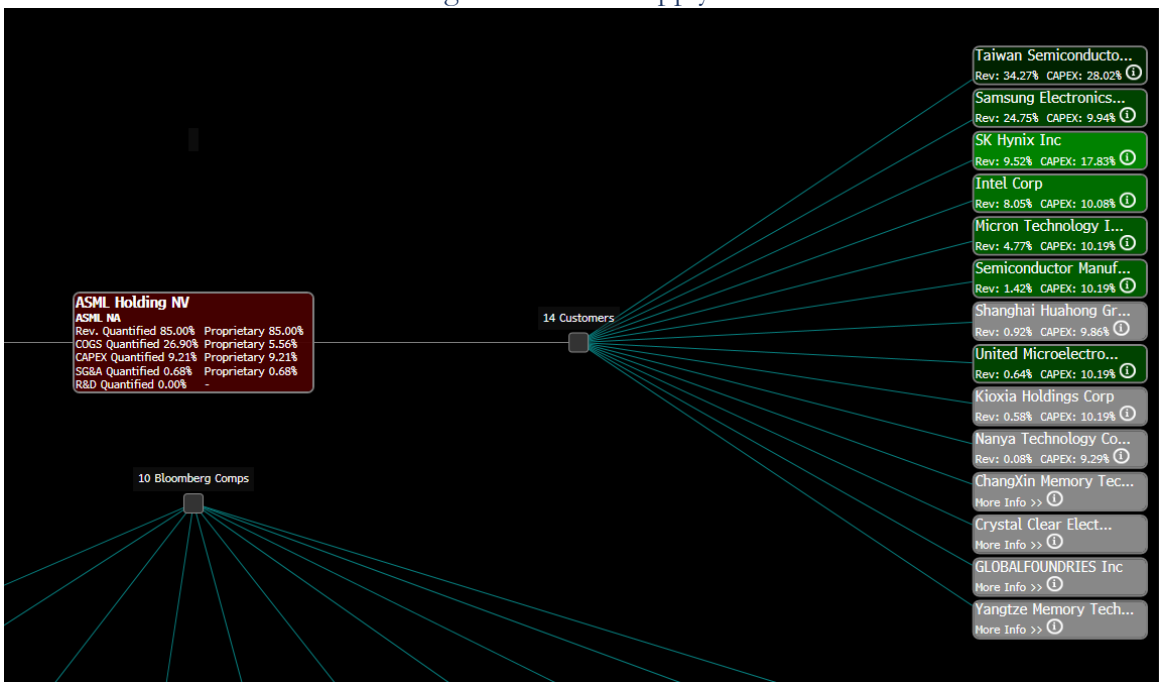


Source: Desjardin[9]

[8] (SIA, 2021)
[9] (Desjardins, 2019)

The biggest concern with the semiconductors and related devices industry is that Moore's Law and the rate of technological growth that has ensued from it, is beginning to slow down. However, the Dutch company ASML has been at the leading edge of chip manufacturing, providing TSMC and Intel with the EUV machines needed to service clients like Apple. The extreme ultra-violet lithography machines have replaced the deep ultra-violet machines before and are packed with over 100,000 individual elements needed to produce the finer 13.5nm light wavelength. Compared to the previous generation of deep-ultraviolet lithography machines using a wavelength of 193nm to etch features into the chips, the advancements made by ASML in this regard are a key factor in our revenue forecasts. As can be seen from the graph of ASML's customer chain below, almost 30% of TSMC's capital expenditure goes directly to ASML alone. Case in point being, the $150m per EUV machine is a necessary outlay to stay at the leading edge and push the boundaries of chip design.

Figure 3: ASML Supply Chain



Source: Bloomberg[10]

The power that ASML holds in this regard is noteworthy when considered with the mounting tensions between the United States and China. As the United States and the Dutch government have restricted ASML's exporting of its latest 5nm to 7nm machines to China, SMIC and China's ambition to make the "Made in China 2025" plan a reality will either require ASML to begin shipping the newest EUV machines, or for China to accelerate its technological advancement in such a dramatic fashion, that they will become independent. The high degree of intricacy implicit in chip manufacturing, as well as the prevalence of "learning by doing" show strong growth potential in the Asian market, but the power still firmly remains in the hands of the United States.

[10] (Bloomberg, 2021D)

Revenues

Overview of revenues

Revenue growth has been volatile but positive in the recent 10 years; the CAGR from 2010 to 2021 has been 7.5%. Furthermore, revenues have grown from $156bn to $347.72bn.

Figure 4: YoY Industry Revenue Growth

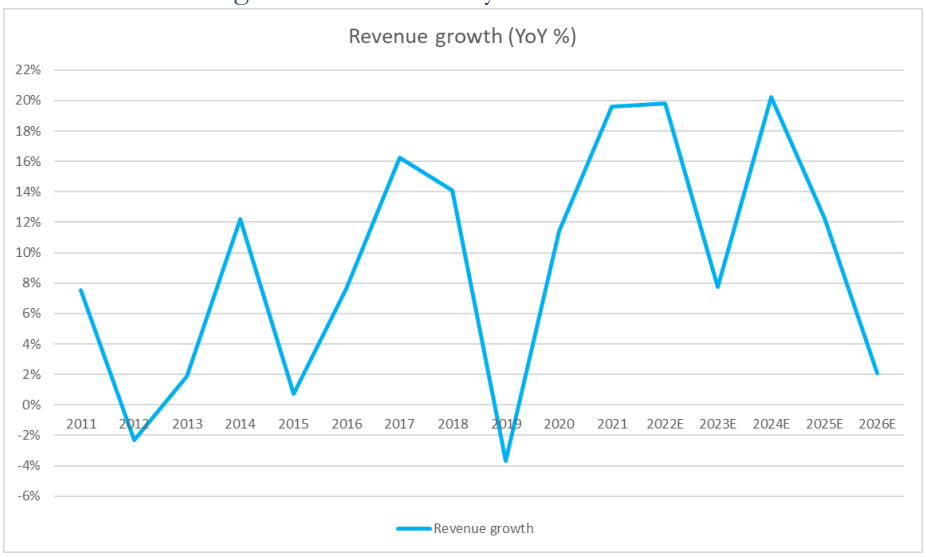
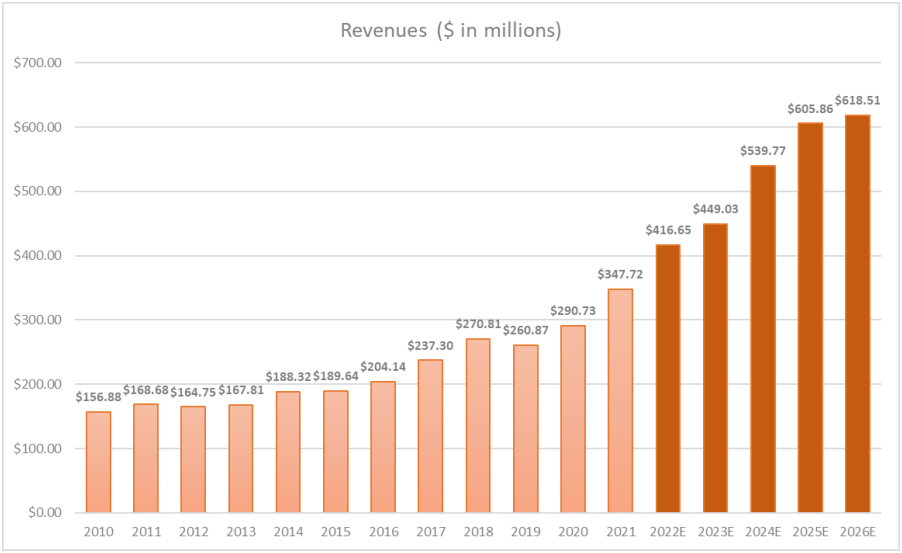


Figure 5: Industry Revenue, in $



Source: Bloomberg (actual)[11], own estimates (forecasts)

Total industry can be derived from 7 segments[12]which include:

- Automotive (7.61%)
- Consumer (11.12%)
- Industrials (18.38 %)
- Computing (29.27%)
- Military (.64%)

[11] (Bloomberg, 2021B)
[12] (Bloomberg, 2021)

- Wired (4.55%)
- Wireless (28.44%)

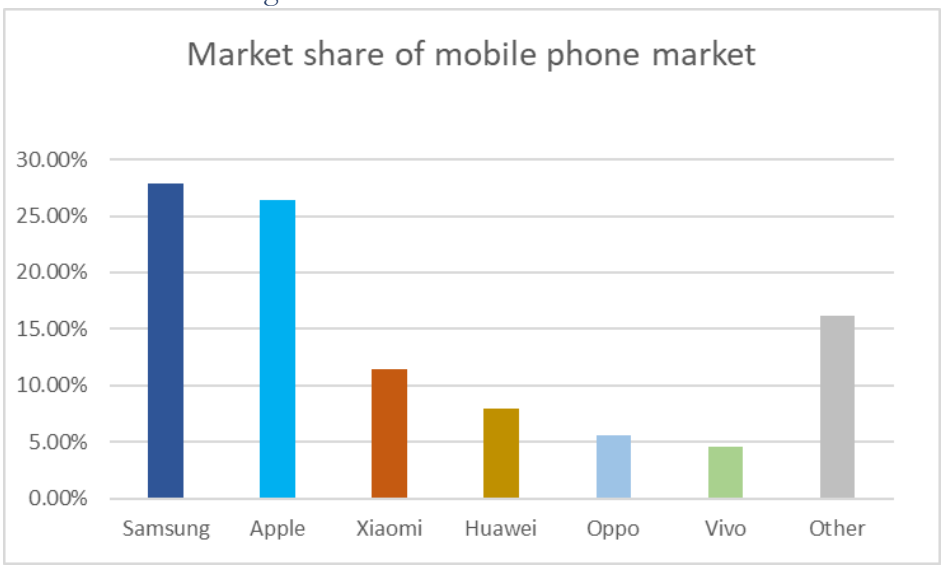
The analysis forecasts each segment to arrive at a total revenue figure for a 5-year forecast window. Wireless, automotive, computing and industrials are segments which will drive future revenues in the industry.

The 5G transformation

5G is the new standard of mobile networks; it is the natural evolution of the 4G network. The benefits of 5G include higher data speeds, ultra-low latency, and increased reliability[13]. These advantages allow 5G to connect an ecosystem of IoT devices which can lead to an increase of the product value through the network effect. 5G coverage is expected to cover 60% of urban centres by 2024[14], which is similar to the past growth of 4G. As such, the wireless device segment growth has been estimated using the growth rate of 4G throughout the period 2017 – 2021. 2017 was chosen as our starting point as it represents the first major year of 4G revenue growth. 2022 is expected to be the corresponding period for 5G as it is fast becoming the standard with Apple, Samsung, Huawei and Xiaomi, or 73.63% of the mobile phone market[15], now having launched 5G devices. The wireless infrastructure to support 5G is estimated using the same method. The drop-off in 4G revenues was calculated using the same approach. The 2.5G revenue decline following 3G's arrival were used to model 4G revenue growth.

These estimates hold true to the KPMG Semiconductor Industry survey where top executives see 5G as a significant driver of revenue growth in the next 1-2 years before dropping off substantially in the following 3 years (Figure 6 below)

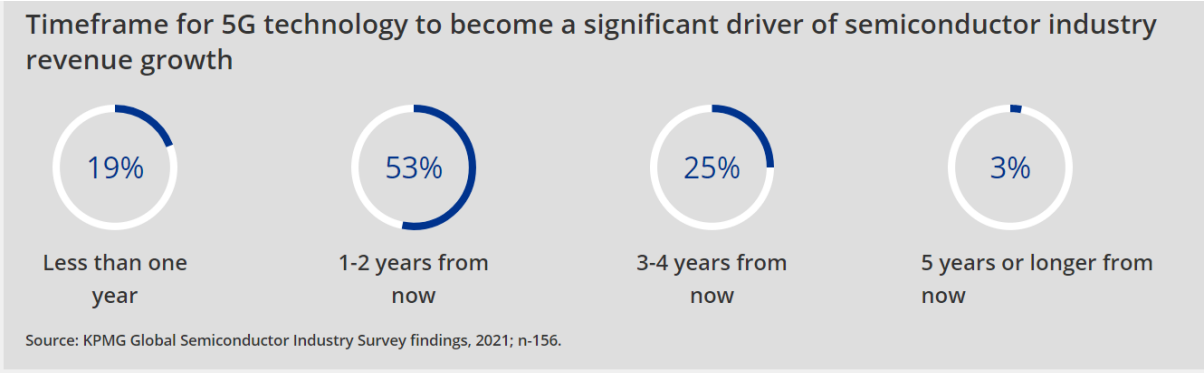
Figure 6: Mobile Phone Market Share



Source GlobalStats-statcounter[16]

[13] (Qualcomm, 2021)
[14] (Goasduff, 2021)
[15] (GlobalStats-statcounter, 2021)
[16] (GlobalStats-statcounter, 2021)

Figure 7: KPMG 2021 Semiconductor Industry Survey



Source: KPMG Global Semiconductor Outlook[17]

Figure 8: Wireless estimated revenue growth

Wireless segment forecasts					
Segment	**2022E**	**2023E**	**2024E**	**2025E**	**2026E**
Wireless	34.79%	7.73%	35.46%	14.37%	-11.82%
Selected segment products (forecasted growth)					
Segment	**2022E**	**2023E**	**2024E**	**2025E**	**2026E**
5G Phones	52.91%	15.36%	47.38%	18.19%	-14.20%
Wireless Infrastructure	28.59%	11.58%	-13.42%	11.76%	22.52%
4G	-5.95%	-23.92%	-28.78%	-33.24%	-29.44%
Selected segment products (past growth)					
Segment	**2017**	**2018**	**2019**	**2020**	**2021**
4G Phones	52.91%	15.36%	47.38%	18.19%	-14.20%
Wireless Infrastructure	28.59%	11.58%	-13.42%	11.76%	22.52%
Segment	**2011**	**2012**	**2013**	**2014**	**2015**
2.5G Phones	-5.95%	-23.92%	-28.78%	-33.24%	-29.44%

Source: own estimates

Figure 9: Forecasted proportion of wireless segment revenues

Segment	**2021**	**2022E**	**2023E**	**2024E**	**2025E**
2G Phones	0.79%	0.61%	0.58%	0.45%	0.40%
3.5G Phones	0.28%	0.22%	0.21%	0.16%	0.14%
3G Phones	0.00%	0.00%	0.00%	0.00%	0.00%
4G Phones	32.02%	23.35%	16.89%	9.40%	5.59%
5G Phones	54.50%	64.62%	70.87%	81.64%	85.89%
Cordless Telephony	0.16%	0.12%	0.12%	0.09%	0.08%
Flash Memory Cards	0.69%	0.56%	0.54%	0.43%	0.40%
Other Wireless	0.00%	0.00%	0.00%	0.00%	0.00%
WLAN Access Points	4.51%	3.64%	3.55%	2.84%	2.59%
WLAN CPE	0.78%	0.63%	0.61%	0.49%	0.45%
Wireless Infrastructure	6.27%	6.25%	6.63%	4.49%	4.47%
Total revenue	100.00%	100.00%	100.00%	100.00%	100.00%

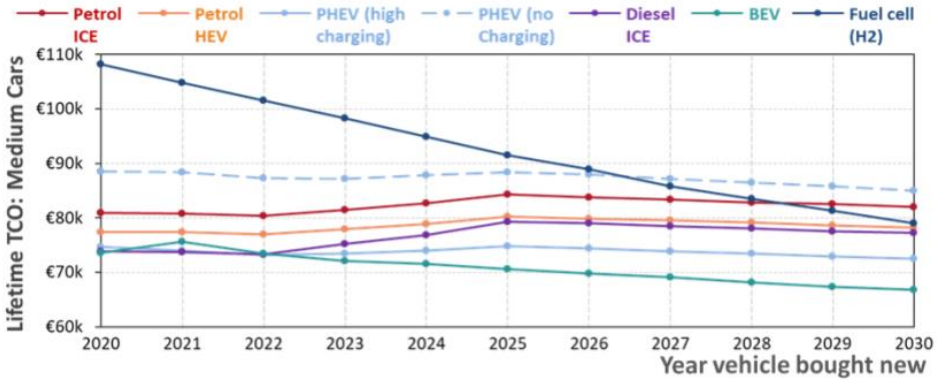
Source: own estimates

[17] (Clark, 2021)

Smart cities and electric cars

The global semiconductor chip shortage has had a detrimental impact on electric car manufacturing and on automotive manufacturing in general; most carmakers had to slow production early in 2021. In the short run, these issues are not expected to improve as chipmakers prefer smartphone, gaming consoles, and other end product users[18]. Despite supply chain struggles, policy makers are setting electric car, which require significantly more chips, than regular vehicles, targets for the medium run. The chips required in an electric car total 3,500 whereas a combustion engine car only requires 1,300 (a 2.69 ratio)[19]. As such, as the proportion of electric vehicles increase, we expect the segment's revenues to increase according to this ratio. US president Biden has stated a target of 50% of new vehicles will be electric by 2030[20]. Ireland, a relative tech laggard, has set a target of 30% by 2030[21]. An estimated reduced total cost of ownership of 8.2%[22], from €73k to €67k, would support this (Figure 10 below).

Figure 10: Estimated total cost of ownership for electric vehicles



Source: Element Energy

The semiconductor supply issue is, however, an overriding factor. Automotive sales have typically grown in line with GDP and as such we have modelled total revenues from automotives to be proportional to GDP. Whilst governments are optimistic for electric car market penetration the logistics aren't clear cut. The U.S will need to install 380 EV charging ports daily until 2030 to have enough capacity for its 2030 target. The lower estimate that 30% of new vehicles will be electric in 2030 was pushed out to 2035 as a result of current chips shortages for the automotive sector and the unrealistic assumptions driving the 50% target set by the US government; 2023 was chosen as the year when EV output will increase as that is when semiconductor supply is expected to be substantially more reliable as a result of foundry investment by Intel and TSMC as elaborated on below when discussing COGS. Thus, we expect flat growth in EVs in 2022.

[18] (Ewing & Boudette, 2021)
[19] (Deloitte, 2021)
[20] (Milman, 2021)
[21] (Barron, 2021)
[22] (Element Energy, 2021)

Figure 11: EV vs Combustion engine proportion of revenues

Line item	2021	2022E	2023E	2024E	2025E	2026E
EV % of revenues	16.84%	16.84%	17.90%	19.30%	20.76%	22.31%
Combustion % of revenues	83.16%	83.16%	82.10%	80.70%	79.24%	77.69%

Source: own estimates. Note: EV represents 7% of sales in 2021 (which accounts for 16.84% of revenues)

Figure 12: Automotive segment projected revenue growth.

Segment	2022E	2023E	2024E	2025E	2026E
Automotives	5.30%	4.78%	3.32%	3.58%	3.66%

Source: own estimates

Figure 13: Automotive segment overview

Automotive projections	
Current market share (Ireland as proxy)	7%
Goal	30% of new vehicles will be electic by 2030
Issue	Infrastructure and chip shortages
Resolution	Increased supply of chips in 2023; slower rollout of
CAGR '23 - 35'	4.13%

Source: own estimates

Next generation gaming and obsolescent technology

The consumer segment of semiconductor revenues consists of outdated technology that is quickly becoming irrelevant in the age of the smartphone. End products include, but are not limited to televisions, gaming consoles, and media tablets. Flat growth is assumed for outdated products which account for miniscule proportions of segment revenue. For e-readers, televisions, and media tablets, this report assumes that they will follow GDP growth of 4.2% in 2022 and 2.6% onwards[23]. Gaming is an area of interest; it is going through an evolution not too dissimilar to the generational updates in 2007 and 2013. The latest edition of high-end consoles, the Xbox One X and the PS5 were released in 2020. Growth rates from 2007, a year after the release of the Xbox 360 and PS3, were used to estimate the gaming sub-segments future revenues. It can be noted that 5G could revolutionise mobile gaming and potentially be detrimental to the growth of fixed gaming consoles. However, these concerns have dwindled with Microsoft and Sony having witnessed record sales, for their Xbox Series X and PS5, respectively[24]. In the face of supply shortages, Sony's PS5 sold 10m units and became the fastest selling console of all time. As such, we expect consoles to follow historical patterns. The chip shortage is also an issue, however, unlike automotives, gaming consoles are a priority for chip makers; thus, it can be expected that upon the resolution of the chip shortage in 2023, gaming console sales will peak.

[23] (Bloomberg, 2021A)
[24] (Tassi, 2021)

Figure 14 Forecasts for fixed game console's revenue 2022-2026

Game console revenue						
Year	2006	2007	2008	2009	2010	2011
Revenue (in millions, $)	$5,269.27	$7,602.40	$7,454.94	$6,425.70	$6,338.77	$5,300.26
YoY Growth	27.62%	44.28%	-1.94%	-13.81%	-1.35%	-16.38%

Source: Bloomberg[25]

Having accounted for flat growth across various end products we arrive at the estimated growth figures for the consumer segment below.

Figure 15: Consume segment overall forecasted growth rates

Segment	2022E	2023E	2024E	2025E	2026E
Consumer	11.19%	0.24%	-2.00%	0.46%	-1.95%

Source: own estimates.

Post Covid-19 personal computing calm

A standard midrange laptop is expected to last for at least 3 years[26], whilst some manufacturers can offer up to 5-year warranties[27]. This is evidenced by the revenue growth cycle in Figure 16 below.

Figure 16: YoY % growth in computing segment revenues

Source: Bloomberg[28]

The cycle was disrupted by covid-19 and the lifespan of a significant proportion of commercial and personal computers have been reset due to a higher level of devices being replaced. As a result, it can be expected that the growth post Covid-19 will revert to the segment mean pre Covid-19. The arrival of Windows 11 in October 2021 would otherwise have allowed for the beginning of a new cycle as early as 2022. This effect is dampened by the fact that a substantial volume of new PCs purchased in 2020 are capable of supporting the new operating system. It is expected that data centre growth will continue its 5-year growth trend of roughly 20% as is demanded by the data required for artificial intelligence and the increasingly reliance on data. Due to the supply shortage, we expect data centres to struggle to keep their growth pace until the situation is resolved

[25] (Bloomberg, 2021B)
[26] (HP, 2018)
[27] (Dell, 2021)
[28] (Bloomberg, 2021)

in 2023. Following on from that the segment, in which data centres account for 45% of revenues in 2021, should return to norm growth of 11.25%.

Figure 17: Computing revenue growth estimates

Segment	2022E	2023E	2024E	2025E	2026E
Computing	6.00%	6.00%	11.25%	11.25%	11.25%

Source: own estimates

Industrial applications

Industrial application of semiconductor chips come mainly in the form of sensors. Whilst such sensors are common sight in vehicles, the driving force of revenues will come via smart cities; such cities are dependent on the success of autonomous vehicles[29]. These vehicles were promised by 2021, but it is well accepted that the expectations within the industry have changed and that a new target of 2030 has been set[30]. Smart cities will be key revenue drivers beyond 2030 as autonomous require data infrastructure, sensors, and communication networks in order to be effective and safe. However, as a result of the perpetual delay of autonomous vehicles it is safe to assume that past segment revenue growth of 6% will be sustained. A large base of data infrastructure exists, and future growth in this sector should precede economic growth. As such, it is expected that the industry will follow historical growth rates and provide a base for the increasingly digitised economy.

Figure 18: Industrial segment estimated growth rate

Segment	2022E	2023E	2024E	2025E	2026E
Industrials	6.00%	6.00%	6.00%	6.00%	6.00%

Source: own estimates

Other products within the segment include point of sale devices which surged in demand following the onset of Covid-19. However, such devices are not chip intensive and represents less than 2% of 2020 segment revenues. Following on from Covid-19, it can be expected than growth in this product will be inconsequential to any valuation.

Figure 19: Industrial segment proportion of product revenues

Product	% of segment revenues
Kiosks	2.34%
Other Industrial Electronics	95.77%
Point of Sale (POS)	1.89%

Source: Bloomberg[31]

Military and wired internet applications

The final 2 segments of semiconductor revenues represent a minute proportion of total revenues. There are not significant developments in either space, or as such it can be assumed that these segments will grow as per GDP, which is in line with historical trends.

[29] (Automotive World, 2021)
[30] (Metz, 2021)
[31] (Bloomberg, 2021)

Figure 20: Semiconductor revenue breakdown

Revenue breakdown by segment	
Segment	**% of 2021 revenues**
Autos	7.61%
Consumer	11.12%
Industrials	18.38%
Computing	29.27%
Military	0.64%
Wired	4.55%
Wireless	28.44%
Total	**100.00%**

Source: Bloomberg[32]

Figure 21: Forecasted revenue growth rates

Segment	2022E	2023E	2024E	2025E	2026E
Military	4.20%	2.60%	2.60%	2.60%	2.60%
Industrials	4.20%	2.60%	2.60%	2.60%	2.60%

Source: own estimates

Total revenue growth methodology

To arrive at a total revenue growth rate for each year, the segment revenues from 2021 were projected forward using their respective growth rates. The forecasted proportions (Figure 22 below). These proportions were used as a weighting on the respective segments growth rate to arrive at a total revenue estimated growth rate for each period (Figure 23 below).

Figure 22: Forecasting segment proportions of revenues

Forecasted proportion of revenues by year						
Segment	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Autos	7.61%	7.01%	6.97%	6.20%	5.86%	6.14%
Consumer	11.12%	10.82%	10.29%	8.69%	7.95%	7.89%
Industrials	18.38%	16.77%	16.59%	14.91%	14.18%	14.96%
Computing	29.27%	27.14%	27.29%	26.16%	26.53%	29.87%
Military	0.64%	0.58%	0.57%	0.50%	0.47%	0.48%
Wired	4.55%	4.15%	4.03%	3.55%	3.32%	3.44%
Wireless	28.44%	33.53%	34.27%	39.99%	41.70%	37.21%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: own estimates

[32] (Bloomberg, 2021)

Figure 23: Total revenue growth rate

Segment weighted growth rates					
Segment	**2022**	**2023**	**2024**	**2025**	**2026**
Autos	0.37%	0.33%	0.21%	0.21%	0.22%
Consumer	1.21%	0.02%	-0.17%	0.04%	-0.15%
Industrials	0.72%	0.71%	0.64%	0.61%	0.64%
Computing	1.63%	1.64%	2.94%	2.98%	3.36%
Military	0.02%	0.01%	0.01%	0.01%	0.01%
Wired	4.20%	2.40%	2.40%	2.40%	2.40%
Wireless	11.67%	2.65%	14.18%	5.99%	-4.40%
Total	19.82%	7.77%	20.21%	12.24%	2.09%

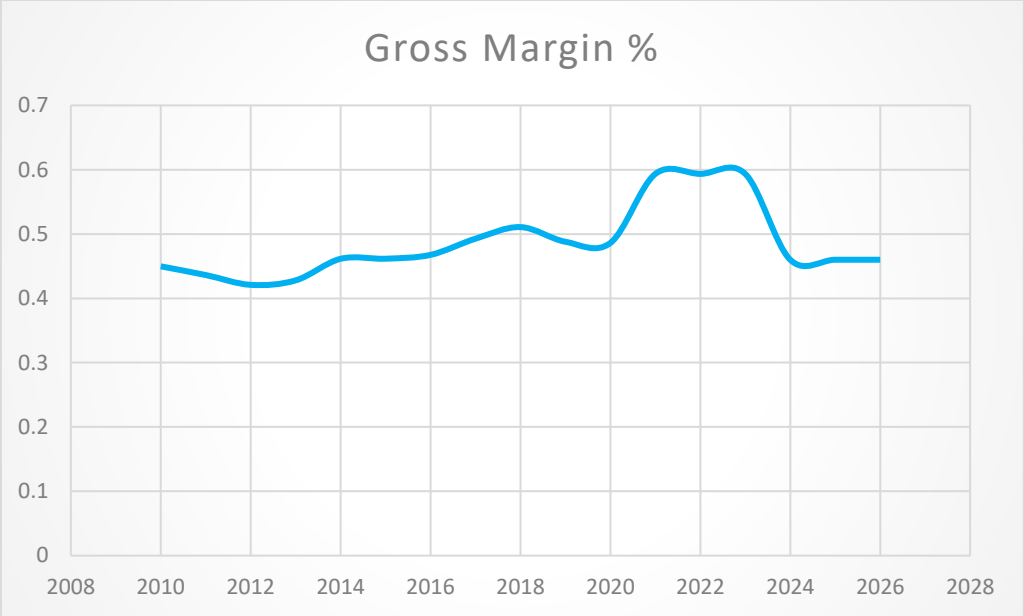
Source: own estimates

Cost of Goods Sold:

Taken as a fraction relative to top line revenue figures, there is evident stability in cost of goods sold, with a median value of 53.5% which we forecast to decline to approximately 40.6% as a result of the increased capacity available through Intel's $20b investment in manufacturing plants in Arizona, Samsung's $116b in expansion over the next decade, as well as TSMC's planned $100b in capital expenditure forecasted over the coming three years. As one of the largest foundries in the world, supplying most major fabless companies, the manufacturing expansion is likely to enable revenue to trace historical figures and track their expected values. As Chief Executive Officer, C.C. Wei has outlined, "demand has significantly outpaced supply", and that the "fabs have been operating at 100% utilisation over the last 12 months"[33]. As a result, we forecast for revenues to climb quicker than cost of goods sold for a period of 3 years until 2024 – followed by a subsequent stabilisation and a return to the historical median value of 46% as the ability to raise prices fades, and final good supply constraints gradually ease. As a result of the additional foundry capacity in 2023 onwards there will be increased raw material supply and we expect gross margins to slowly fall back to historical levels. This should increase the level of competition in the end-product marketplace and result in an aggregate consumer end-product prices which are lower than in the preceding years as well as lower margins which these smaller players operate on. Whilst the cost of silicon has skyrocketed in recent months, we do not expect this to have an effect on overall margins, especially not in the long run. Whilst chips are made almost entirely using silicon the actual cost that silicon represents in end-products is minute compared to the equipment, IP rights, and labour costs of creating such end-products[34] as evidenced by the high costs of purchasing capital equipment such as ASML's EUV machines.

[33] (Wu, 2021)
[34] (Semi, 2021)

Figure 24: Industry Gross Margins



Selling, General, and Administration Expenses

With regards to the selling, General, and Administration expenses, once again, taken in conjunction to revenue growth, a 7.5% constant rate has been projected forward due to the stability of this ratio over the previous decade. Overall, considering that the industry is heavily dominated by its manufacturing process, as opposed to marketing and other expenses, we see no significant reason as to why the historical precedent will not carry forward towards 2026.

Taxation

A taxation rate of 11% has been consistent across all companies and locations. As a result, there is no basis for which to assume that this will change in the lead up to 2026. Company guidance also suggests 11% across all major companies within the industry.

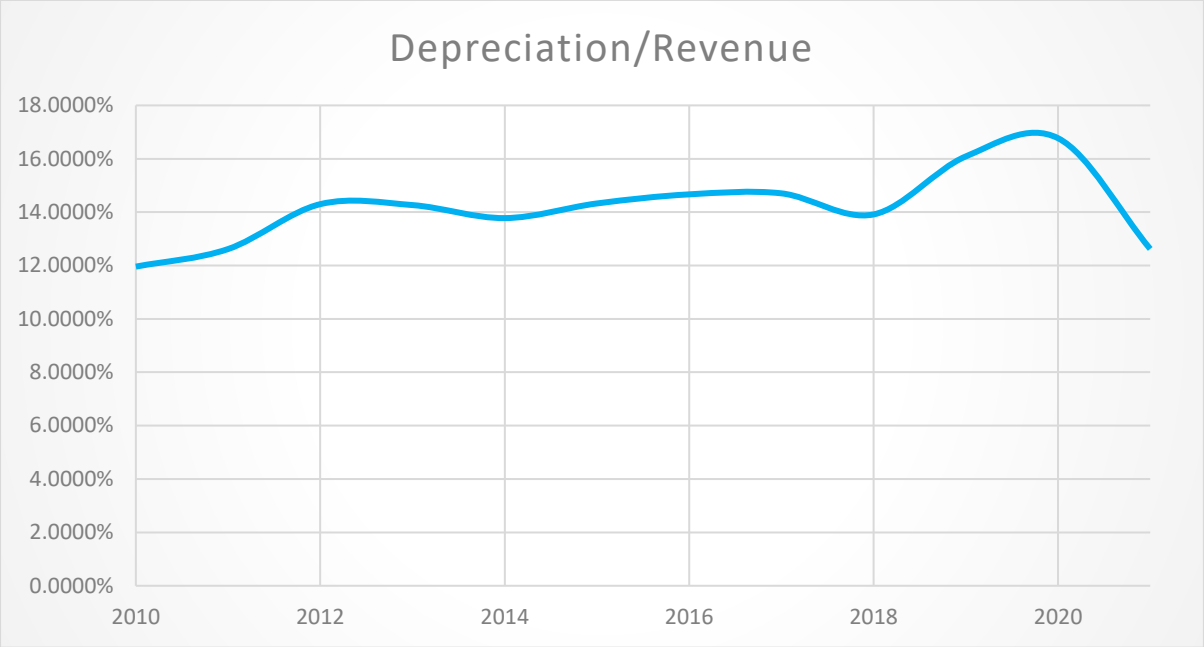
Interest Expenses

Interest expenses were modelled in proportion to short and long-term debt and the average of 3.2% was chosen as our projected interest rate moving forward into 2022 and onwards to 2026. The cost of debt figure used in our adjusted present value calculation has also incorporated this 3.2%.

Depreciation & Amortisation:

With regards to depreciation and amortisation as a percentage of revenue, there has a been a relatively stable pattern evident over the last decade as can be seen from the chart below: As such the historical average of 14.17% was taken as the forecast of depreciation to revenue in the 2022-26 forecast window.

Figure 25: Depreciation to revenue ratio

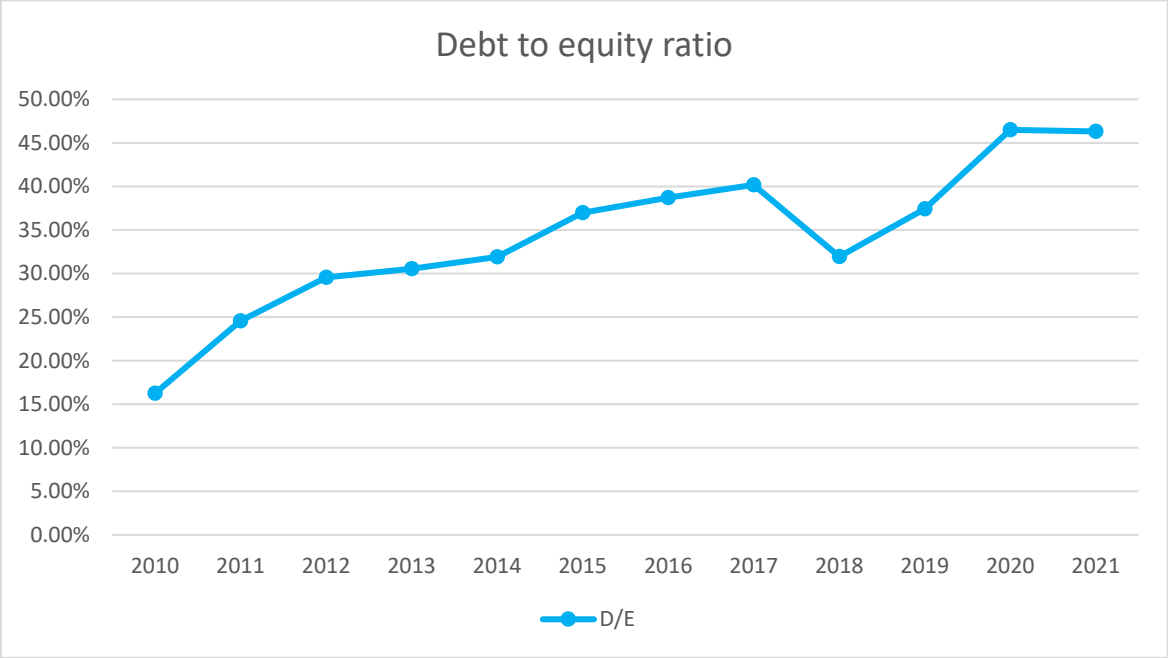


Short/Long Term Debt and Capital Expenditure

In relation to debt figures, our projections have been modelled using projected industry growth rates, capital expenditure figures from each of the companies' individual guidance estimates, as well as an analysis of individual cash flow statements. In addition to this, the planned capital expenditure by some of the larger players in the industry, specifically, TSMC, Intel, and Samsung have served as a proxy for industry expansion over the last decade as a result of the overall market share that each of these companies command.

As the assumption of constant D/E at an industry level did not hold, the adjusted present value approach was used to value the industry.

Figure 26: Industry Debt to equity ratio



Source: Bloomberg[35]

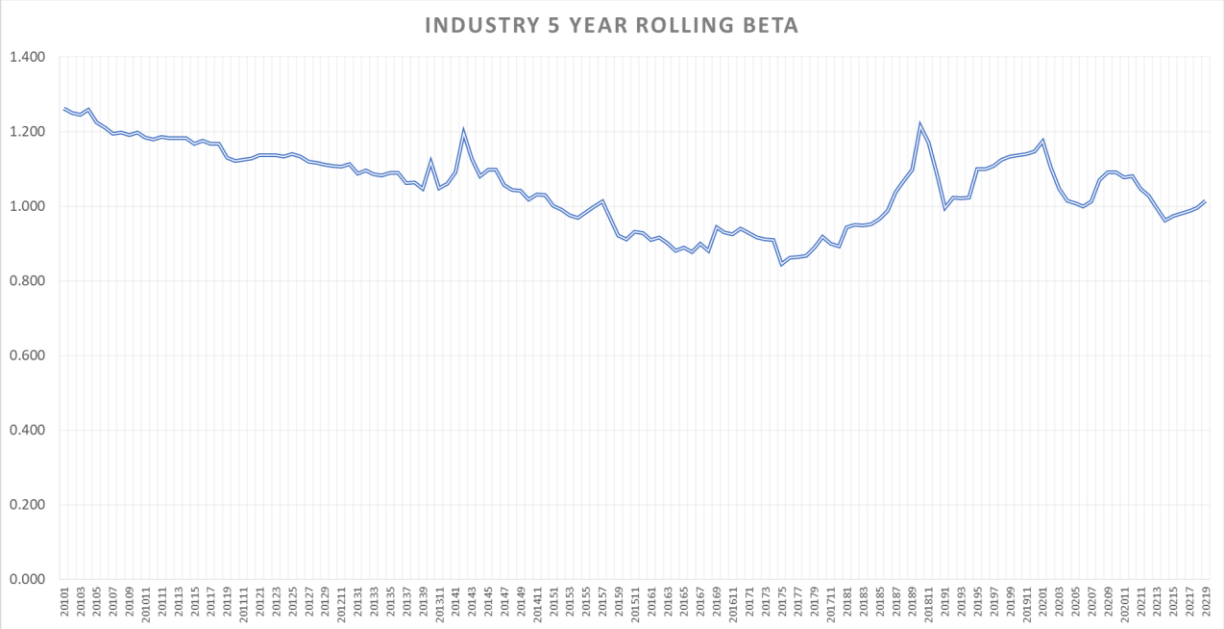
Cost of equity:

In order to calculate the cost of equity, individual betas for each company were calculated using monthly returns data for the individual stocks versus the index of Wilshire 5000.

These betas were subsequently weighted by their market cap as a % of total industry market cap and summed together in order to calculate the industry unlevered beta. The most recent beta of 1.01 was used as the basis for the cost of equity calculation.

[35] (Bloomberg, 2021B)

Figure 27: Industry Rolling Beta



Source: Yahoo Finance[36]

The unlevered beta was calculated using the current D/E ratio of the industry of .5472 and an unlevered beta of .652 was arrived at. The market risk premium of 5.5% from Statista[37] was used to calculate the cost of equity. The 10yr US treasury yield as of 27th September of 1.5% was used as the risk-free rate (with a .25% downward adjustment to account for the liquidity premium).

Figure 28: Inputs to APV valuation

Inputs		
Cost of unlevered equity		4.84%
Perpetual g		2.50%
Cost of equity		
Risk free rate		1.25%
Market risk premium		5.50%
Levered Beta		0.97
Unlevered Beta		0.6523
D/E Ratio 2021		0.5473
Tax rate		11.00%
Cost of equity		5.37%

Source: Fred[38], Bloomberg[39], Bloomberg[40], Bloomberg[41]

[36] (Yahoo Finance, 2021)
[37] (Statista, 2021)
[38] (FRED, 2021)
[39] (Bloomberg, 2021A)
[40] (Bloomberg, 2021B)
[41] (Bloomberg, 2021C)

Moreover, FCFF was calculated for each forecast period up until 2026 as per figure 30 below. Additionally, the cost of equity was utilised to determine discount factors for each forecast period as per figure 32.

CapEx was arrived at using guidance of $35bn spending by TSMC in 2022 and 2023, as well as guidance CAPEX by Intel in 2022 of $20bn. The residual industry CapEx was arrived at using historical industry norms during periods of expansion, which is assumed to be the case. To calculate the overall industry CapEx, historical periods which were similar to the current period were identified to determine the appropriate CapEx spend as a proportion of net PP&E. Historical periods which were used as a proxy for the next 5 years of CapEx were identified as periods which occurred after the launch of many core industry products. These products include the latest Windows, upgraded games console, next-generation processors, and wireless communication systems (e.g., 3G, 4G, and 5G launches). As per figure 29 below TSMC's and Intel's PP&E were excluded from the calculation in 2022 as guidance estimates for their spends are known. Similarly, in 2023, TSMC's net PP&E was excluded for the same reason.

Figure 29: CapEx calculation

in millions, $	CAPEX Forecasts						
Line item	**2021**	**2022E**	**2023E**	**2024E**	**2025E**	**2026E**	**Note**
CAPEX %		38.09%	38.09%	38.09%	29.63%	33.88%	Based on historical figures and industry trend
CAPEX $		$83,405.12	$93,163.95	$106,292.45	$95,516.17	$117,228.73	
PP&E Gross		$279,115.12	$330,342.33	$386,464.94	$419,981.73	$466,467.98	
Depreciation		21.43%	21.62%	22.57%	22.29%	22.57%	
		$41,936.74	$50,169.84	$61,999.38	$70,742.48	$76,885.81	Calculated using previous year PP&E
Net PP&E	$195,710.00	$237,178.38	$280,172.49	$324,465.56	$349,239.25	$389,582.17	
Calculations							
Year 1 CAPEX	($195,710-$121136.3)*49.94% + $35,000 (TSMC spend) + $20,000 (Intel)						(Previous Year's Total PP&E - Intel and TSMC PP&E)*38.09% (expected CAPEX) + TSMC and Intel CAPEX
Year 2 CAPEX	($237,178.38 - TSMC PP&E of $84,477.02)*38.09% + $35,000 (TSMC CAPEX)						(Previous Year's Total PP&E - TSMC PP&E)*38.09% (expected CAPEX) + TSMC CAPEX
Year 3 CAPEX	$280,172.49*38.09%						Previous Year's Total PP&E*38.09%
Year 4 CAPEX	$324,172.49*29.63%						Previous Year's Total PP&E*29.63%
Year 5 CAPEX	$349,239.25*33.88%						Previous Year's Total PP&E*33.88%

Source: own calculations, Bloomberg[42] (company guidance)

As per figure 30 below, the EBITDA to FCFF approach was utilised to calculate unlevered cash flows. Inventories are the most volatile component of NWC and as such were used as the proxy for NWC investments. Inventory turnover has been declining in recent years due to supply issues. This trend is expected to reverse and revert to a conservative historical norm, as per figure 31, as the supply issues in the industry begin to dampen. Capital Investment was arrived at using the CapEx spend calculated in figure 29 above.

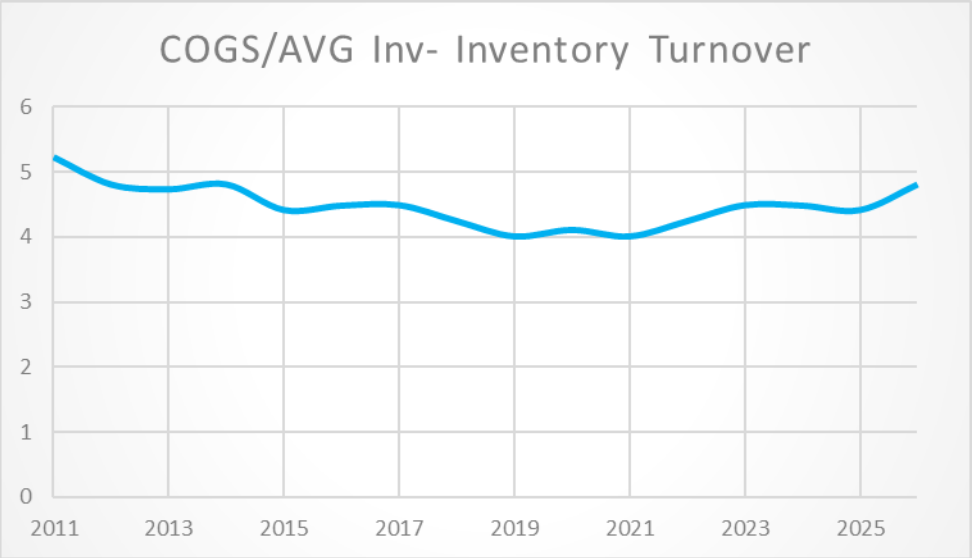
Figure 30: FCFF calculation

in millions, USD	2022E	2023E	2024E	2025E	2026E
EBITDA	$200,029.30	$210,178.04	$185,061.42	$204,999.76	$194,630.44
EBITDA*(1-t)	$178,026.07	$187,058.45	$164,704.66	$182,449.78	$173,221.09
D&A(t)	$6,434.83	$6,934.52	$8,293.94	$9,212.59	$9,223.41
FCInv	$83,405.12	$93,163.95	$106,292.45	$95,516.17	$117,228.73
NWCInv	$7,783.33	$1,093.10	$22,482.66	$8,703.41	$3,265.14
FCFF	$93,272.45	$99,735.92	$44,223.49	$87,442.79	$61,950.63

[42] (Bloomberg, 2021C)

Source: own estimates

Figure 31: Inventory turnover



The FCFFs were discounted using the cost of equity in figure 28 above, and the terminal value was arrived at using a terminal growth rate of 2.5% which is a Bloomberg estimate for long term GDP.

Figure 32: Industry valuation calculations

in millions, $	2022E	2023E	2024E	2025E	2026E
FCFF	$93,272.45	$99,735.92	$44,223.49	$87,442.79	$61,950.63
Discount factor	0.95386	0.90984	0.86786	0.82781	0.78961
Discounted FCFF	$88,968.54	$90,743.96	$38,379.76	$72,386.28	$48,917.13
Terminal value	$2,144,964.83				
Discounted terminal value	$1,693,695.92				
Equity value	$2,033,091.58				
Tax shield	$3,976.31				
Total industry value	$2,037,067.89				
Market capitalisation	$2,250,000.00				

Source: own estimates

The tax shield was calculated using a historical average interest/debt ratio as a proxy for the cost of debt for the industry. The risk of default in the industry is low as evidenced by the predominantly A rated companies within our revenue weighted industry sample. As a result, this proxy was assumed to be a suitable estimate. The total debt figure for the previous fiscal year was used to calculate the current period's interest payments. Furthermore, the tax shield was calculated using an 11% tax rate as per the average guidance figures provided by the largest companies' executives.

Figure 33: Tax shield calculation

in millions, $		Tax shield (in millions)					Note
	2021	2022E	2023E	2024E	2025E	2026E	
Total debt	$164,661.83	$203,422.81	$236,400.92	$275,138.29	$250,010.15	$294,182.24	See: debt note
Cost of debt	3.20%	3.20%	3.20%	3.20%	3.20%	3.20%	10 yr average
Interest payment		$5,269.18	$6,509.53	$7,564.83	$8,804.43	$8,000.32	Calculated using previous year's debt
Tax rate	11%	11%	11%	11%	11%	11%	Executive guidance, Bloomberg
Tax shield		$579.61	$716.05	$832.13	$968.49	$880.04	
Total tax shield	**$3,976.31**						

Source: own calculations

Thus, an estimated industry value of $2.037tn was arrived at as per figure 33. This entails a SELL recommendation with downside risk of 9.46%% versus the current market capitalisation of $2.25tn[43] (as of September 27th, 2021).

[43] (Bloomberg, 2021E)

Appendices

Appendix 1: Forecasts for EBITDA, Debt, Income Statement

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
	$53,107.24	$54,305.23	$49,708.58	$52,152.05	$67,641.85	$68,564.16	$71,969.05	$94,099.58	$117,944.76	$107,696.45	$123,234.92	$158,457.31	$199,621.16	$211,950.27	$188,492.31	$211,171.30	$204,791.34
	33.85%	32.19%	30.17%	31.08%	35.92%	36.15%	35.25%	39.65%	43.55%	41.28%	42.39%	45.57%	0.479822573	0.469212956	0.345037146	0.341924223	0.32106918
	$18,760.60	$21,283.48	$23,557.82	$23,937.69	$25,943.96	$27,166.74	$29,940.10	$34,892.23	$37,680.75	$41,966.42	$48,757.54	$43,885.07	$58,939.35	$63,994.62	$77,393.99	$87,495.25	$90,363.37
	$34,346.65	$33,021.75	$26,150.76	$28,214.36	$41,697.89	$41,397.43	$42,028.95	$59,207.35	$80,264.01	$65,730.03	$74,477.37	$114,572.24	$140,681.81	$147,955.66	$111,098.32	$123,676.05	$114,427.97

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
	$18,551.22	$30,288.07	$39,358.05	$44,657.51	$48,806.18	$60,728.40	$76,389.01	$89,754.40	$81,084.54	$96,325.05	$139,681.31	$148,359.84	$188,422.81	$221,400.92	$260,138.29	$235,010.15	$279,182.24
	$5,903.23	$6,882.04	$6,872.54	$7,011.03	$6,815.36	$11,371.85	$10,463.95	$14,511.88	$10,518.06	$14,710.34	$14,351.93	$16,301.99	$15,000.00	$15,000.00	$15,000.00	$15,000.00	$15,000.00
	$24,454.46	$37,170.11	$46,230.59	$51,668.55	$55,621.54	$72,100.25	$86,852.96	$104,266.28	$91,602.61	$111,035.40	$154,033.24	$164,661.83	$203,422.81	$236,400.92	$275,138.29	$250,010.15	$294,182.24

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022E	2023E	2024E	2025E	2026E
	$156,881.54	$168,684.73	$164,746.17	$167,813.71	$188,321.37	$189,641.55	$204,143.37	$237,300.73	$270,807.46	$260,868.10	$290,726.32	$347,720.00	$416,031.20	$451,714.46	$546,295.70	$617,596.77	$637,841.80
reciation and amortisation)	$86,317.06	$95,093.30	$95,388.03	$96,006.79	$101,411.88	$102,095.60	$108,681.53	$120,370.58	$132,484.40	$133,571.90	$149,394.75	$141,347.06	$169,115.34	$183,620.47	$294,999.68	$333,502.26	$344,434.57
	$70,564.48	$73,591.43	$69,358.14	$71,806.92	$86,909.50	$87,545.95	$95,461.84	$116,930.15	$138,323.06	$127,296.19	$141,331.56	$206,372.94	$246,915.85	$268,093.98	$251,296.02	$284,094.52	$293,407.23
	44.98%	43.63%	42.10%	42.79%	46.15%	46.16%	46.76%	49.28%	51.08%	48.80%	48.61%	59.35%	59.35%	59.35%	46.00%	46.00%	46.00%
	$16,923.04	$18,631.21	$19,190.33	$19,047.49	$18,841.36	$18,749.60	$19,454.67	$19,144.23	$19,474.00	$20,274.84	$21,185.57	$26,917.51	$31,618.37	$34,330.30	$41,518.47	$46,937.35	$48,475.98
	$19,294.79	$21,938.47	$24,017.05	$24,545.08	$26,370.25	$27,398.92	$33,978.22	$38,578.57	$38,585.05	$41,291.32	$45,668.62	$64,883.19	$74,615.67	$85,808.02	$98,679.23	$113,481.11	$130,503.28
	$34,346.65	$33,021.75	$26,150.76	$28,214.36	$41,697.89	$41,397.43	$42,028.95	$59,207.35	$80,264.01	$65,730.03	$74,477.37	$114,572.24	$140,681.81	$147,955.66	$111,098.32	$123,676.05	$114,427.97
	21.89%	19.58%	15.87%	16.81%	22.14%	21.83%	20.59%	24.95%	29.64%	25.20%	25.62%	32.95%	33.82%	32.75%	20.34%	20.03%	17.94%
													$5,269.18	$6,509.53	$7,564.83	$8,804.43	$8,000.32
													$14,895.39	$15,559.07	$11,388.68	$12,635.88	$11,707.04
er adjustments	$6,936.65	$6,383.03	$9,446.95	$5,490.80	$9,968.51	$7,049.11	$13,407.40	$14,372.72	$499.15	$9,365.43	$9,417.68	$28,094.40	$20,164.57	$22,068.60	$18,953.51	$21,440.30	$19,707.37
	$27,409.99	$26,638.72	$16,703.81	$22,723.56	$31,729.38	$34,348.31	$28,621.56	$44,834.63	$79,764.86	$56,364.61	$65,059.70	$86,477.84	$120,517.24	$125,887.06	$92,144.81	$102,235.75	$94,720.61

Appendix 2: Segment Weight as a Proportion of Total Revenue

Proportion of revenues by segment						
Segment	**Proportion of total 2021 revenue**	**2022**	**2023**	**2024**	**2025**	**2026**
Autos	7.61%	6.83%	7.44%	7.36%	7.70%	8.92%
Consumer	11.12%	10.84%	10.24%	8.58%	7.80%	7.66%
Industrials	18.38%	16.80%	16.51%	14.73%	13.90%	14.52%
Computing	29.27%	27.19%	27.15%	25.83%	26.01%	28.98%
Military	0.64%	0.59%	0.56%	0.49%	0.46%	0.47%
Wired	4.55%	4.16%	4.01%	3.51%	3.25%	3.34%
Wireless	28.44%	33.60%	34.09%	39.50%	40.88%	36.11%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Appendix 3: Segment Weighted Growth Rate

Segment weighted growth rates					
Segment	**2022**	**2023**	**2024**	**2025**	**2026**
Autos	0.16%	1.17%	1.15%	1.21%	1.40%
Consumer	1.21%	0.02%	-0.17%	0.04%	-0.15%
Industrials	0.72%	0.71%	0.63%	0.60%	0.62%
Computing	1.63%	1.63%	2.91%	2.93%	3.26%
Military	0.02%	0.01%	0.01%	0.01%	0.01%
Wired	4.20%	2.40%	2.40%	2.40%	2.40%
Wireless	11.69%	2.63%	14.01%	5.87%	-4.27%
Total	19.65%	8.58%	20.94%	13.05%	3.28%

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