BofA GLOBAL RESEARCH

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Taiwan Semiconductor Manufacturing Co.

2024 YA: Advancing at steady pace; reiterate Buy and NT$760 PO

Reiterate Rating: BUY | PO: 760.00 TWD | Price: 586.00 TWD

Reiterate Buy with PO of NT$760

Backed by improving foundry S/D and TSMC's solid technology leadership, we reiterate Buy on TSMC. We find the current valuation attractive at 15x/12x 2024/25E P/E and see good opportunity given the strong fundamentals vs. the share-price underperformance in 2023 against SOX. The rising AI applications, solid 2024 guidance, and increasing IDM outsourcing could be catalysts.

2024E up 23% on AI/PC/handset and IDM outsourcing

Due to easing inventory headwinds, we expect TSMC to deliver 23% revenue growth in 2024, driven by 3nm ramp, CoWoS expansion, and demand recovery, along with solid market share. HPC and smartphone are likely to boost the UTRs of 3nm and 5nm, when Intel's outsourcing likely gradually contributes (Exhibit 40). We expect TSMC's mature node UTR to be higher than peers, thanks to its specialty offerings. Despite depreciation and FX, we expect TSMC to offset the shortfall and maintain GPM >53% in 2024 on yield improvement, cost reduction, and value-generation efforts.

Leading edge to outperform mature nodes

While we expect the foundry industry to recover 14% YoY after a low-base 2023, advanced nodes led by TSMC are expected to grow 31% YoY, thanks to structural growth of AI/PC along with cyclical recovery of PC/smartphone semis outpacing mature nodes, which are expected to only grow 2% capped by competition pressure.

4Q preview: expect solid GPM and strong 1Q guidance

We expect 4Q EPS of NT$8.9 (vs. consensus NT$8.7). Into 1Q24, we expect only 6% QoQ revenue decline guidance (consensus: down 7% QoQ) and gross margin of ~51.5% (consensus: 51%). TSMC will host 4Q earnings call on Jan 18. We tweak our 2023/24E EPS estimates by +0.4%/-3% to reflect 4Q23 actual revenue, lower UTR and unfavorable FX into 2024.

Estimates (Dec) (NT$)	2021A	2022A	2023E	2024E	2025E
Net Income (Adjusted - mn)	596,540	1,016,530	829,460	1,012,712	1,251,227
EPS	23.0	39.2	32.0	39.1	48.3
EPS Change (YoY)	15.2%	70.4%	-18.4%	22.1%	23.6%
Dividend / Share	11.00	11.00	13.00	14.25	15.50
Free Cash Flow / Share	10.5	20.4	12.0	29.5	37.8
ADR EPS (US$)	4.12	6.58	5.14	6.27	7.75
ADR Dividend / Share (US$)	1.97	1.85	2.09	2.29	2.49
Valuation (Dec)					
P/E	25.5x	14.9x	18.3x	15.0x	12.1x
Dividend Yield	1.9%	1.9%	2.2%	2.4%	2.6%
EV / EBITDA*	13.7x	9.4x	10.1x	8.2x	6.7x
Free Cash Flow Yield*	1.8%	3.5%	2.0%	5.0%	6.5%

* For full definitions of *iQmethod*^{SM} measures, see page 36.

Timestamp: 15 January 2024 11:33AM EST

15 January 2024

Equity

Key Changes

(NT$)	Previous	Current
2023E EPS	31.85	31.99
2024E EPS	40.35	39.05
2023E EBITDA (m)	1,444,057	1,448,162
2024E EBITDA (m)	1,838,850	1,796,303
2025E EBITDA (m)	2,205,873	2,200,640

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Stock Data

Price (Common / ADR)	586.00 TWD / 101.24 USD
Price Objective	760.00 TWD / 130.00 USD
Date Established	3-Oct-2023 / 15-Jan-2024
Investment Opinion	B-1-7 / B-1-7
52-Week Range	489.00 TWD-594.00 TWD
Market Value (mn)	488,215 USD
Market Value (mn)	15,196,194 TWD
Shares Outstanding (mn)	25,932.1 / 5,186.4
Average Daily Value (mn)	513.86 USD
Free Float	92.0%
BofA Ticker / Exchange	TSMWF / TAI
BofA Ticker / Exchange	TSM / NYS
Bloomberg / Reuters	2330 TT / 2330.TW
ROE (2023E)	25.7%
Net Dbt to Eqty (Dec-2022A)	-23.7%

Semis - Global: Foundry S/D monitor: 2024 Year Ahead - Steady growth seen driven by leading edge 15 Jan 2024

Please refer to Exhibit 65 on page 33 for acronyms

iQprofile^{SM} Taiwan Semiconductor Manufacturing Co.

Key Income Statement Data (Dec)	2021A	2022A	2023E	2024E	2025E
(NT$ Millions)					
Sales	1,587,415	2,263,891	2,161,736	2,663,643	3,210,434
Gross Profit	819,537	1,348,355	1,176,124	1,420,792	1,762,552
Sell General & Admin Expense	(44,488)	(63,445)	(70,895)	(68,005)	(88,157)
Operating Profit	649,981	1,121,279	919,605	1,144,082	1,426,330
Net Interest & Other Income	13,145	22,912	51,388	49,488	48,040
Associates	NA	NA	NA	NA	NA
Pretax Income	663,126	1,144,191	970,992	1,193,570	1,474,370
Tax (expense) / Benefit	(66,053)	(127,290)	(141,944)	(181,319)	(223,609)
Net Income (Adjusted)	596,540	1,016,530	829,460	1,012,712	1,251,227
Average Fully Diluted Shares Outstanding	25,930	25,931	25,932	25,932	25,932
Key Cash Flow Statement Data					
Net Income	596,540	1,016,530	829,460	1,012,712	1,251,227
Depreciation & Amortization	422,395	437,254	528,557	652,221	774,310
Change in Working Capital	(110,281)	(64,994)	8,982	(46,194)	(62,778)
Deferred Taxation Charge	NA	NA	NA	NA	NA
Other Adjustments, Net	203,507	221,809	(60,001)	53,048	20,458
Cash Flow from Operations	1,112,161	1,610,599	1,306,998	1,671,787	1,983,218
Capital Expenditure	(839,196)	(1,082,672)	(996,609)	(906,258)	(1,001,860)
(Acquisition) / Disposal of Investments	4,400	(130,522)	(28,699)	(7,503)	(469)
Other Cash Inflow / (Outflow)	(1,570)	22,266	62,613	133	419
Cash Flow from Investing	(836,366)	(1,190,928)	(962,695)	(913,629)	(1,001,909)
Shares Issue / (Repurchase)	0	0	0	0	0
Cost of Dividends Paid	(259,304)	(285,238)	(285,248)	(337,117)	(369,532)
Cash Flow from Financing	136,608	(200,244)	(250,724)	(325,002)	(366,694)
Free Cash Flow	272,965	527,927	310,388	765,529	981,358
Net Debt	(455,588)	(703,075)	(792,921)	(1,218,069)	(1,830,102)
Change in Net Debt	(13,970)	(135,238)	(83,291)	(421,042)	(611,776)
Key Balance Sheet Data					
Property, Plant & Equipment	1,975,119	2,693,837	3,207,350	3,437,820	3,637,498
Other Non-Current Assets	143,312	218,045	254,641	258,473	258,838
Trade Receivables	198,301	231,340	204,386	215,222	234,438
Cash & Equivalents	1,188,456	1,561,486	1,687,949	2,125,213	2,740,083
Other Current Assets	220,316	260,071	274,782	324,785	379,013
Total Assets	3,725,503	4,964,779	5,629,107	6,361,513	7,249,870
Long-Term Debt	613,380	839,096	884,304	897,925	901,000
Other Non-Current Liabilities	201,887	220,967	230,758	459,626	521,948
Short-Term Debt	119,488	19,314	10,725	9,218	8,981
Other Current Liabilities	620,015	924,913	980,280	1,004,196	1,024,225
Total Liabilities	1,554,770	2,004,290	2,106,068	2,370,966	2,456,154
Total Equity	2,170,733	2,960,489	3,523,040	3,990,547	4,793,716
Total Equity & Liabilities	3,725,503	4,964,779	5,629,107	6,361,513	7,249,870
iQmethod^{SM} **- Bus Performance***					
Return On Capital Employed	22.1%	28.5%	19.2%	20.4%	21.7%
Return On Equity	29.7%	39.8%	25.7%	27.1%	28.6%
Operating Margin	40.9%	49.5%	42.5%	43.0%	44.4%
EBITDA Margin	67.6%	68.8%	67.0%	67.4%	68.5%
iQmethod^{SM} **- Quality of Earnings***					
Cash Realization Ratio	1.9x	1.6x	1.6x	1.7x	1.6x
Asset Replacement Ratio	2.0x	2.5x	1.9x	1.4x	1.3x
Tax Rate (Reported)	10.0%	11.1%	14.6%	15.2%	15.2%
Net Debt-to-Equity Ratio	-21.0%	-23.7%	-22.5%	-30.5%	-38.2%
Interest Cover	NM	NM	NM	NM	NM

Key Metrics

* For full definitions of *iQmethod*^{SM} measures, see page 36.

Company Sector

Semiconductors

Company Description

TSMC was founded in 1987 and is listed in Taiwan (2330TT) and the US (TSM/NYS).TSMC is the largest and global leader in integrated circuit (IC) manufacturing. As a build-to-order foundry, it provides a wide range of value-add activities: IC manufacturing, mask-making, IC design services, turnkey solutions, and process development. We attribute its success to its proven, winning business model, unparalleled scale advantage, optimized execution, and technology scope and depth. 5 shares = 1 ADR.

Investment Rationale

The ongoing semi content growth in mobile, rise of artificial intelligence (AI), and proliferation of Internet of Things (IoT) should result in sustainable upside in aggregate computing power globally. TSMC, as the leading contract manufacturer of semiconductor chips, is in a good position to capitalize. We are structurally positive on TSMC and expect it to sustain over 15% growth with rising FCF and dividends during 2021-25E.

Stock Data

Shares / ADR	5.00
Price to Book Value	4.3x

Key Changes

(US$)	Previous	Current
Price Obj.	125.00	130.00
2023E EPS	5.12	5.14
2024E EPS	6.48	6.27

Well-grounded recovery for semis industry

After an 11% YoY global semis sales correction in 2023E, impacted by prolonged inventory digestion and weak macro, BofA now projects 15% YoY rebound into 2024, with semis ex-memory and memory registering 48% and 8% growth, respectively (Exhibit 1). We expect the semis ex-memory market recovery in 2024 to be a mild one, driven by gradual demand stabilization and structural generative AI upside, and supported by eased pressure from inventory digestion exiting 2023 for most of the sub-sectors. By device type, we expect logic/microprocessors (MPU) to be the strongest segments in semis ex-memory areas, with 15-16% YoY growth in 2024E, while analog to be the weakest with 7% YoY contraction, due to the ongoing inventory digestion (last-in, last-out).

Exhibit 1: We model MPUs. Logic components driving semiconductor growth
Summary of BofA semis estimates by device type

Revenue ($bn)	2016	2017	2018	2019	2020	2021	2022	2023E	2024E	2025E	2026E	CAGR '23-26E	CAGR '18-23	CAGR '13-23
Total Semis	$338.9	$412.2	$468.8	$412.3	$440.4	$555.6	$573.7	$511.5	$589.2	$670.8	$691.6	10.6%	1.8%	5.3%
YoY%	1.1%	21.6%	13.7%	(12.0%)	6.8%	26.2%	3.3%	(10.8%)	15.2%	13.9%	3.1%			
Memory	$76.8	$124.0	$158.0	$106.4	$117.5	$153.8	$129.8	$89.3	$132.0	$166.2	$152.4	19.5%	(10.8%)	2.9%
YoY%	(0.6%)	61.5%	27.4%	(32.6%)	10.4%	30.9%	(15.6%)	(31.2%)	47.8%	25.9%	(8.3%)			
DRAM	$41.2	$72.8	$99.3	$62.5	$64.3	$93.0	$77.8	$50.3	$75.3	$97.1	$88.0	20.5%	(12.7%)	3.8%
YoY%	(8.4%)	76.8%	36.4%	(37.1%)	3.0%	44.5%	(16.3%)	(35.3%)	49.6%	29.0%	(9.4%)			
NAND	$32.0	$47.2	$54.2	$40.2	$49.4	$56.0	$47.1	$34.8	$52.5	$64.2	$59.2	19.4%	(8.5%)	2.4%
YoY%	11.0%	47.5%	14.8%	(25.9%)	22.9%	13.3%	(15.9%)	(26.1%)	50.8%	22.4%	(7.8%)			
Core Semis (ex-memory)	$262.2	$288.2	$310.8	$305.9	$322.9	$401.8	$443.9	$422.3	$457.2	$504.6	$539.2	8.5%	6.3%	5.9%
YoY%	1.6%	9.9%	7.8%	(1.6%)	5.6%	24.4%	10.5%	(4.9%)	8.3%	10.4%	6.9%			
Analog	$47.8	$53.1	$58.8	$53.9	$55.7	$74.1	$89.0	$80.1	$74.2	$79.8	$83.7	1.5%	6.4%	7.2%
YoY%	5.8%	10.9%	10.8%	(8.2%)	3.2%	33.1%	20.1%	(10.0%)	(7.4%)	7.6%	4.9%			
Microprocessors	$43.1	$44.3	$46.9	$48.0	$51.8	$58.0	$51.0	$44.1	$50.9	$53.7	$56.3	8.5%	(1.2%)	0.7%
YoY%	(0.3%)	2.7%	5.9%	2.3%	8.0%	12.0%	(12.0%)	(13.6%)	15.4%	5.5%	4.8%			
Microcontrollers	$14.6	$16.3	$17.1	$15.8	$15.5	$19.6	$25.0	$27.7	$27.6	$30.0	$32.1	5.1%	10.1%	6.6%
YoY%	(5.9%)	12.2%	4.4%	(7.4%)	(2.0%)	26.7%	27.6%	10.5%	(0.2%)	8.7%	7.0%			
DSP	$2.9	$3.3	$3.3	$2.7	$2.4	$2.8	$3.2	$3.2	$3.2	$3.3	$3.5	2.9%	(0.2%)	1.1%
YoY%	12.5%	14.5%	(0.6%)	(18.6%)	(10.4%)	19.4%	13.1%	0.5%	(0.3%)	3.2%	6.0%			
Logic	$91.5	$102.3	$109.3	$106.5	$118.4	$154.2	$176.0	$169.9	$196.9	$226.1	$247.4	13.3%	9.2%	7.1%
YoY%	0.8%	11.7%	6.9%	(2.5%)	11.1%	30.2%	14.2%	(3.5%)	15.9%	14.8%	9.4%			
Discretes, optos, sensors	$62.2	$69.0	$75.5	$79.0	$79.2	$93.0	$99.6	$97.2	$104.4	$111.7	$116.2	6.1%	5.2%	6.1%
YoY%	2.6%	10.9%	9.4%	4.6%	0.3%	17.4%	7.1%	(2.3%)	7.4%	6.9%	4.1%			

Source: BofA Global Research, Gartner, Omdia, SIA

Application-wise, we anticipate server semis to outgrow, up 36% YoY in 2024E, driven by strong semis content gains and aided by continued AI deployment. PC semis are expected to rebound by 14% YoY in 2024, following 9%/22% YoY drop in 2022A/23E, thanks to a broad-based demand recovery and generally normalized PC-related inventory. In contrast, we foresee a weak 2024 demand outlook for industrial, dragged by concerns around industrial production and inventory.

Exhibit 2: We model semis/core semis sales up 15%/8% YoY after a weak CY23
Summary of BofA semiconductor estimates by end-market

Revenue ($bn)	2016	2017	2018	2019	2020	2021	2022	2023E	2024E	2025E	2026E	CAGR '23-26E	CAGR '18-23	CAGR '13-23
Total Semis	$338.9	$412.2	$468.8	$412.3	$440.4	$555.6	$573.7	$511.5	$589.2	$670.8	$691.6	10.6%	1.8%	5.3%
YoY%	1.1%	21.6%	13.7%	(12.0%)	6.8%	26.2%	3.3%	(10.8%)	15.2%	13.9%	3.1%			
Memory	$76.8	$124.0	$158.0	$106.4	$117.5	$153.8	$129.8	$89.3	$132.0	$166.2	$152.4	19.5%	(10.8%)	2.9%
YoY%	(0.6%)	61.5%	27.4%	(32.6%)	10.4%	30.9%	(15.6%)	(31.2%)	47.8%	25.9%	(8.3%)			
Core Semis (ex-memory)	$262.2	$288.2	$310.8	$305.9	$322.9	$401.8	$443.9	$422.3	$457.2	$504.6	$539.2	8.5%	6.3%	5.9%
YoY%	1.6%	9.9%	7.8%	(1.6%)	5.6%	24.4%	10.5%	(4.9%)	8.3%	10.4%	6.9%			
Compute and Storage	$82.7	$89.8	$100.6	$96.7	$107.6	$128.0	$129.2	$119.6	$149.1	$172.7	$188.8	16.4%	3.5%	3.4%
YoY%	(0.2%)	8.6%	12.0%	(3.8%)	11.2%	19.1%	0.9%	(7.4%)	24.6%	15.8%	9.3%			
PCs	$40.6	$43.4	$48.8	$47.6	$55.5	$67.9	$61.8	$48.0	$54.8	$59.7	$61.3	8.5%	(0.3%)	0.7%
YoY%	1.0%	6.9%	12.5%	(2.3%)	16.5%	22.3%	(9.0%)	(22.3%)	14.1%	9.0%	2.7%			
Units (mn)	260	260	260	268	304	350	298	257	267	282	287			
YoY%	(5.7%)	(0.2%)	(0.1%)	3.2%	13.5%	15.1%	(14.9%)	(13.7%)	3.7%	5.8%	1.7%			
ASPs ($/PC)	$156	$167	$188	$178	$183	$194	$208	$187	$205	$212	$214			
YoY%	7.0%	7.1%	12.5%	(5.3%)	2.7%	6.2%	7.0%	(10.0%)	10.0%	3.0%	1.0%			
Servers (silicon only)	$18.6	$20.7	$26.2	$26.6	$27.3	$31.7	$36.6	$43.3	$59.0	$75.1	$90.0	27.6%	10.6%	12.4%
YoY%	6.9%	11.0%	26.6%	1.7%	2.4%	16.2%	15.6%	18.5%	36.1%	27.4%	19.8%			
Units (mn)	9.6	10.2	11.8	11.8	12.7	13.5	15.0	14.9	16.3	17.6	18.8			
YoY%	(1.6%)	7.2%	15.7%	(0.4%)	7.6%	6.3%	11.1%	(0.4%)	8.8%	8.4%	6.5%			
ASPs ($/server)	$1,946	$2,017	$2,207	$2,255	$2,146	$2,345	$2,439	$2,903	$3,628	$4,263	$4,796			
YoY%	8.6%	3.6%	9.4%	2.1%	(4.8%)	9.3%	4.0%	19.0%	25.0%	17.5%	12.5%			
Wireless Communications	$65.7	$71.2	$72.2	$76.6	$85.1	$104.0	$111.1	$103.1	$112.5	$120.7	$126.4	7.0%	7.4%	5.7%
YoY%	0.2%	8.4%	1.4%	6.1%	11.1%	22.3%	6.8%	(7.2%)	9.2%	7.3%	4.7%			
Smartphone	$56.8	$59.5	$60.3	$62.5	$70.6	$87.5	$91.1	$86.5	$97.6	$104.3	$109.3	8.1%	7.5%	8.9%
YoY%	6.9%	4.7%	1.3%	3.7%	13.0%	24.0%	4.1%	(5.1%)	12.9%	6.8%	4.8%			
Units (mn)	1454	1472	1388	1389	1286	1346	1211	1150	1201	1246	1280			
YoY%	1.8%	1.2%	(5.7%)	0.1%	(7.4%)	4.7%	(10.1%)	(5.1%)	4.5%	3.7%	2.7%			
ASPs ($/phone)	$39	$40	$43	$45	$55	$65	$75	$75	$81	$84	$85			
YoY%	5.0%	3.5%	7.5%	3.5%	22.1%	18.4%	15.8%	0.0%	8.0%	3.0%	2.0%			
Wireless Infrastructure	$8.9	$11.7	$11.9	$14.1	$14.5	$16.5	$20.0	$16.6	$14.9	$16.4	$17.2	1.1%	6.8%	6.5%
YoY%	(10.3%)	31.7%	2.1%	18.6%	2.3%	14.0%	21.0%	(17.0%)	(10.0%)	10.0%	4.5%			
Automotive	$32.7	$35.9	$39.4	$37.7	$34.3	$46.1	$58.3	$64.7	$67.3	$72.9	$79.5	7.1%	10.4%	9.7%
YoY%	8.5%	9.7%	9.9%	(4.3%)	(9.1%)	34.6%	26.4%	10.9%	4.1%	8.3%	9.0%			
Global Auto Units (mn)	93.1	95.2	94.2	89.0	74.6	77.2	82.0	89.2	88.9	90.4	92.1	1.1%	(1.1%)	0.5%
YoY%	4.8%	2.2%	(1.0%)	(5.6%)	(16.1%)	3.5%	6.2%	8.8%	(0.3%)	1.7%	1.9%			
Auto semi content ($/LV)	$351	$377	$418	$424	$459	$597	$711	$725	$758	$807	$863	6.0%	11.6%	9.1%
YoY%	3.5%	7.4%	11.0%	1.3%	8.4%	30.0%	19.0%	2.0%	4.5%	6.5%	7.0%			
Industrial & Other	$34.3	$41.1	$45.9	$43.9	$42.8	$54.1	$65.4	$63.4	$51.7	$57.2	$60.8	(1.4%)	6.7%	11.6%
YoY%	2.6%	20.0%	11.6%	(4.3%)	(2.6%)	26.5%	20.8%	(2.9%)	(18.5%)	10.7%	6.2%			
Automation	$7.4	$9.3	$10.6	$10.1	$9.8	$12.7	$14.8	$14.7	$13.5	$15.1	$16.4	3.6%	6.8%	11.6%
YoY%	4.0%	25.8%	13.8%	(4.4%)	(3.0%)	29.5%	17.0%	(1.0%)	(8.0%)	12.0%	8.0%			
Power/Energy	$4.2	$5.2	$5.9	$5.8	$5.8	$7.2	$8.8	$9.3	$9.0	$9.9	$10.9	5.5%	9.3%	16.4%
YoY%	3.8%	21.7%	15.2%	(2.4%)	(0.5%)	25.4%	22.0%	5.0%	(3.0%)	10.0%	10.0%			
Consumer	$28.9	$32.1	$34.1	$32.9	$35.1	$48.2	$52.3	$44.6	$47.9	$50.4	$51.4	4.9%	5.5%	3.5%
YoY%	(2.2%)	10.9%	6.4%	(3.6%)	6.5%	37.5%	8.5%	(14.7%)	7.5%	5.2%	2.0%			
TVs	$9.7	$8.7	$11.1	$9.3	$10.3	$14.1	$14.4	$11.4	$12.0	$13.6	$13.8	6.7%	0.6%	1.5%
YoY%	(8.7%)	(10.6%)	27.0%	(15.8%)	10.5%	37.1%	1.8%	(20.8%)	5.1%	13.4%	2.0%			
Video console SoCs (Gaming)	$2.1	$3.4	$2.8	$1.7	$4.1	$7.1	$8.2	$6.4	$5.7	$5.4	$5.5	(5.0%)	17.9%	-
YoY%	22.2%	61.2%	(16.5%)	(38.3%)	132.2%	74.3%	15.9%	(21.3%)	(11.1%)	(5.7%)	2.3%			
Wired Communications	$17.9	$18.2	$18.6	$18.0	$18.2	$21.3	$27.7	$26.9	$28.6	$30.7	$32.3	6.3%	7.6%	6.0%
YoY%	8.9%	1.5%	2.1%	(3.1%)	1.0%	17.0%	30.2%	(3.1%)	6.4%	7.3%	5.2%			
Ethernet/Network switch	$6.1	$6.1	$6.0	$5.1	$4.9	$5.5	$7.4	$8.3	$9.1	$10.0	$10.5	8.3%	6.6%	3.6%
YoY%	11.6%	0.2%	(0.7%)	(15.3%)	(3.8%)	11.9%	35.0%	12.0%	10.0%	10.0%	5.0%			
Optical Equipment	$2.0	$3.1	$3.1	$3.8	$4.2	$4.7	$5.9	$5.3	$5.9	$6.3	$6.6	7.6%	11.1%	9.4%

Source: BofA Global Research, Gartner, Omdia, SIA

HPC and AI to lead the 2024 growth

Heading into 2024, we highlight HPC and smartphone applications to serve as key drivers, amid the normalized inventory and structural uptrend, along with higher ASP content driven by the rising AI adoptions.

Exhibit 3: TSMC's 2024E revenue mix and content growth potentials by application
We see semis content growth potential in the majority of TSMC's focus areas, primary driven by AI

Major applications	Est. TSMC '24E rev mix	Semi content growth
Smartphone platform	**35-40%**	o o o
HPC platform	**40-45%**	o o o
PC/NB/tablet	20-25%	o o o
Datacenter/server	10-15%	o o o
Game console	MSD %	o o
Base station	LSD %	o o o
Crypto	LSD %	o
IoT platform	**8-10%**	o o o
Automotive platform	**5-10%**	o o o
DCE platform	**0-5%**	o o
Others	**0-5%**	o

Source: BofA Global Research estimates, company data

AI: structural uptrend on both cloud and end-device sides

On the cloud side, we see NVIDIA continue to lead AI development, with new-gen products like B100 entering the market in 2024, along with Habana Gaudi 3, Google TPU v5, etc. (Exhibit 4). Fueled by increases in CoWoS capacity by TSMC in 2024, we expect the cloud AI chipsets to continue growing substantially. On top of NVIDIA, AMD's MI300 series and some new AI ASIC offerings by start-ups will also gain more traction this year. In general, we see the structural uptrend for cloud AI to continue and lead to 50%+ CAGR for TSMC in 2024/25.

Exhibit 4: AI accelerators that use HBM memory
Lots of GPU line-ups for AI training/inference, but HBM3/3e memory still mostly for NVIDIA's GPU, followed by AMD's; Google's new TPU v5e still uses HBM2

Company	Name	Type	AI function	Launch date	DRAM spec	Remarks
NVIDIA	X100	GPU	AI training	2025	HBM4	Next gen of B100 using HBM4 (2TB/sec) likely
	B100	GPU	AI training	2H24	144GB+ HBM3e	Next gen of H100 using HBM3e (1.2TB/sec); TSMC's 3nm wafer output likely in 4Q24
	H200	GPU	AI training	2Q24	141GB HBM3e	Likely the first GPU with HBM3e (1.2TB/s) memory
	GH200 v2	GPU	AI training	2Q24	144GB HBM3e	2nd gen of GH200 using "HBM3e (1.2TB/sec)"
	H20	GPU	AI training	1Q24	96GB HBM3; 4TB/s	Despec version of H100 for China export; key difference is computing power, while HBM memory spec slightly upgraded
	L2	GPU	AI training/inference	Jan 2024	24GB GDDR6; 300GB/s	Also, despec version of L40S for China export; lower bandwidth vs L20
	GH200	GPU	AI training	Dec 2023	96GB HBM3	Superchip based on both GPU+HBM3 and CPU+LPDDR5
	L20	GPU	AI training/inference	Dec 2023	48GB GDDR6; 864GB/s	Despec version of L40S for China export; major difference is computing power, while no difference in memory spec
	L40S	GPU	AI training/inference	Oct 2023	48GB GDDR6; 864GB/s	No HBM, just GDDR6 used but 1.2x/1.7x better AI inference/training vs A100
	H100 NVL	GPU	AI training	Sep 2022	188GB HBM3; 7.8TB/s	Powerful AI training GPU using 188GB HBM3
	H100 SXM5	GPU	AI training	Sep 2022	80GB HBM3; 3.35TB/s	High-speed AI training GPU (900GB/sec) PCIe / NVL (600GB/sec)
	H100 PCIe	GPU	AI training	Sep 2022	80GB HBM2e; 2TB/s	Still based on HBM2e - HBM3 not yet
	A100	GPU	AI training	Jun 2020	40/80GB HBM2/2e; 2TB/s	Old gen but still actively used for AI training
AMD	MI300X	APU	AI training	Jun 2023	192GB HBM3; 5.2 TB/s	More advanced version vs MI300
	MI300	APU	AI training	Jan 2023	128GB HBM3; 1.2TB/s	Combination of CPU+GPU
	Genoa-X	CPU	HPC	1H23	12-channel DDR5; 460GB/s	High-performance computing; limited AI training
	Genoa	CPU	Datacenter	4Q22	12-channel DDR5; 460GB/s	Broadly for data center
Xilinx	Versal	FPGA	AI inference	Mar 2022	32GB HBM2e; 819.2Gb/s	Xilinix was acquired by AMD for US$49bn => deal completed in Feb 2022
Intel	Gaudi3	GPU	AI training	TBD	100GB+ HBM3 or 3e possible	Target to compete with NVIDIA H100
	Gaudi2	GPU	AI training	May 2022	96GB HBM2e; 2.45TB/s	Stated stronger than NVIDIA A100
	Gaudi	GPU	AI training	NA	32GB HBM2; 1TB/s	
	Xeon Max SR	GPU	AI training	Jan 2023	128GB HBM2e; 1TB/s	Only GPU; high-performance computing, and AI training
Meta	MTIA v1	ASIC	AI inference	May 2023	LPDDR5 128GB	AI accelerator - to be better than GPU
Amazon	Inferentia2	ASIC	AI inference	2H22	32GB HBM2e	More advanced AI inference vs 2019 generation
	Trainium	ASIC	AI training	2H22	32GB HBM2e; 1.6TB/s	Used for training AI models in cloud
Google	TPU v5	ASIC	AI training	2024	HBM3 or 3e	Launch date and HBM specs not yet confirmed
	TPU v5e	ASIC	AI training	Aug 2023	16GB HBM2	Pre-version of v5 2024; good for AI training combining tens of thousands of v5e TPUs

Exhibit 4: AI accelerators that use HBM memory

Lots of GPU line-ups for AI training/inference, but HBM3/3e memory still mostly for NVIDIA's GPU, followed by AMD's; Google's new TPU v5e still uses HBM2

Company	Name	Type	AI function	Launch date	DRAM spec	Remarks
	TPU v4	ASIC	AI training	May 2022	32GB HBM2	Claimed to be more efficient vs Nvidia's A100
Alibaba	Hanguang 800	NPU	AI inference	Sep 2019	not mentioned	Mainly for Alibaba AI inference
Biren	BR104	GPU	AI training/inference	Sep 2023	32GB HBM2e	HBM3 not yet adopted; memory content also low at 32GB
	BR100	GPU	AI training	Aug 2022	64GB HBM2e	China's new AI training and also inference
Enflame	T20	ASIC	AI training	Jul 2021	32/64GB HBM2E	Mainly for China AI training
Cambricon	MLU370	ASIC	AI inference	Mar 2022	48GB LPDDR5	Mainly for AI inference

Source: Companies, media reports, BofA Global Research estimates

As pointed out in our previous end-device AI report, we have seen industry-leading chipmakers (Qualcomm, MediaTek, etc.) endeavoring to adopt generative AI functions on smartphones, headsets, PCs, etc., and we expect more to come in 2024. We expect AI to revolutionize end-devices in the foreseeable future, to provide more timely, customized, and private services to end-users. This is likely to lead to strong semiconductor (the enabler of AI) upgrade for end-devices, and potentially ignite a massive replacement cycle. We estimate end-device AI to post 93% CAGR in 2023-25E to contribute 2%/4% of TSMC's revenue in 2024/25E.

Exhibit 5: Aggregate end-device AI TAM summary for TSMC

We estimate aggregate end-device AI TAM to be US$1.2/1.9/4.4bn (99/186/487k wafers) for TSMC in 2023/24/25, or 2%/2%/4% revenue contribution

	Unit	2023	2024	2025
Smartphone/tablet Assistive AI TAM for TSMC	US$bn	1.1	1.1	1.1
Smartphone/tablet Generative AI TAM for TSMC	US$bn	0.0	0.4	2.2
AIoT TAM for TSMC	US$bn	0.1	0.2	0.8
Automotive AI TAM for TSMC	US$bn	0.0	0.1	0.3
Total TAM for TSMC	US$bn	1.2	1.9	4.4
BofAe TSMC revenue	US$bn	69	85	102
Smartphone/tablet Assistive AI contribution to BofAe TSMC revenue	%	2%	1%	1%
Smartphone/tablet Generative AI contribution to BofAe TSMC revenue	%	0%	1%	2%
AIoT contribution to BofAe TSMC revenue	%	0%	0%	1%
Automotive AI contribution to BofAe TSMC revenue	%	0%	0%	0%
Total potential contribution for TSMC	%	2%	2%	4%
Smartphone/tablet Assistive AI wafer consumption for TSMC	k wafers	70	74	76
Smartphone/tablet Generative AI wafer consumption for TSMC	k wafers	1	26	128
AIoT wafer consumption for TSMC	k wafers	24	76	252
Automotive AI wafer consumption for TSMC	k wafers	5	10	32
Total wafer consumption for TSMC	k wafers	99	186	487

Source: BofA Global Research estimates

Smartphone: AI user experience key

We have seen slowdown in node migration in smartphone SoCs (e.g., Apple adopts new 3nm only on iPhone 15 Pro/Pro Max series), due to the marginal upgrades in user experience of new SoCs over the past few years. In this case, the key for next wave of smartphone demand upcycle, in our view, could be the user experience of additional AI functions. We notice that all the major smartphone Android brands are aggressively expanding generative AI functions, by collaborating with SoC vendors from chip design stage and building their own large language models.

Our Global Team estimates 2024 global smartphone shipment to grow 5% YoY. Back in 2H23, we saw the smartphone market recovery, mainly based in China (YoY rise in Sept/Oct/Nov domestic shipments, Huawei's mass production of Mate 60, higher exports to emerging markets) and partially due to iPhone (+4% YoY in 4Q23E). We currently estimate only +3% due to domestic demand risk. We assume relatively strong 2024 recovery for Samsung and Apple (+7%/+10% vs -12%/-5% in 2023) given their large ex-China sales exposure. We eye on semiconductor content upside with the growing AI adoptions.

Server: modest shipment growth in 2024

Tech demand was strong in 2021 (COVID-19) but weakened in 2022-23, with a low correlation to GDP fluctuation. Lots of currently in-use devices, including servers, are beyond their product life cycles. Thus, our Global Team assumes positive shipment growth for most tech products in 2024 (replacement cycle) despite global/US macro risks. Our US Semiconductors team recently updated the global cloud capex tracker (Exhibit 6), assessing spending trends across major US and China cloud/internet service providers. Consensus suggests strong global cloud capex rebound following weak 2023E (US$164.6bn, -2% YoY), with 2024E capex at US$196.5bn, +19% YoY (above US$192.8bn prior), showing an encouraging recovery trend.

Exhibit 6: Summary of cloud capex expectations
Consensus is now forecasting cloud capex to grow nearly 20% in '24E

	C1Q23	C2Q23	C3Q23	C4Q23E	C1Q24E	C2Q24E	C3Q24E	C4Q24E	C1Q25E	C2Q25E	C3Q25E	C4Q25E	2022	2023E	2024E	2025E
CapEx ($mn)																
Total US	36,573	35,415	39,494	45,205	43,890	44,659	45,221	49,757	47,887	48,141	49,285	56,829	157,932	156,687	183,527	202,141
Google	6,289	6,888	8,055	9,955	8,668	8,895	9,144	9,932	9,260	9,384	9,754	11,168	31,485	31,187	36,638	39,565
Microsoft	6,607	8,943	11,103	10,356	10,713	11,254	11,125	11,378	11,443	12,004	11,871	12,307	24,768	37,009	44,469	47,625
Amazon	14,207	11,455	12,479	14,282	14,386	13,971	14,672	17,304	16,423	15,543	16,566	21,200	63,645	52,423	60,333	69,732
Meta	6,842	6,216	6,543	8,419	7,820	8,082	8,283	9,047	8,611	8,897	9,082	10,093	31,356	28,020	33,232	36,683
Oracle	2,628	1,913	1,314	2,191	2,303	2,457	1,998	2,096	2,151	2,313	2,012	2,060	6,678	8,046	8,854	8,536
Total China	1,197	1,746	2,145	2,829	2,679	3,265	3,570	3,500	2,865	3,581	3,750	3,939	9,410	7,917	13,015	14,134
Alibaba	366	828	564	1,247	1,199	1,969	2,040	1,509	1,267	2,138	2,086	1,673	5,490	3,005	6,716	7,164
Tencent	642	545	1,097	1,268	1,154	957	1,137	1,566	1,322	1,069	1,210	1,755	2,703	3,552	4,814	5,356
Baidu	189	373	484	314	327	339	393	425	275	374	454	511	1,217	1,360	1,484	1,614
Total	37,770	37,161	41,639	48,034	46,569	47,924	48,792	53,257	50,752	51,722	53,035	60,768	167,342	164,603	196,542	216,275
YoY %																
Total US	-0.1%	-7.8%	-3.7%	7.9%	20.0%	26.1%	14.5%	10.1%	9.1%	7.8%	9.0%	14.2%	20.9%	-0.8%	17.1%	10.1%
Google	-35.7%	0.9%	10.7%	31.1%	37.8%	29.1%	13.5%	-0.2%	6.8%	5.5%	6.7%	12.4%	27.8%	-0.9%	17.5%	8.0%
Microsoft	23.7%	30.2%	76.7%	65.1%	62.1%	25.8%	0.2%	9.9%	6.8%	6.7%	6.7%	8.2%	6.7%	49.4%	20.2%	7.1%
Amazon	-5.0%	-27.1%	-23.8%	-13.9%	1.3%	22.0%	17.6%	21.2%	14.2%	11.2%	12.9%	22.5%	4.2%	-17.6%	15.1%	15.6%
Meta	25.7%	-17.9%	-30.1%	-6.3%	14.3%	30.0%	26.6%	7.5%	10.1%	10.1%	9.7%	11.6%	68.3%	-10.6%	18.6%	10.4%
Oracle	138.7%	34.4%	-23.6%	-10.0%	-12.4%	28.4%	52.1%	-4.4%	-6.6%	-5.9%	0.7%	-1.7%	114.2%	20.5%	10.0%	-3.6%
Total China	-58.2%	-28.0%	-1.7%	45.9%	123.9%	87.0%	66.5%	23.7%	6.9%	9.7%	5.0%	12.5%	-27.2%	-15.9%	64.4%	8.6%
Alibaba	-74.8%	-50.1%	-63.4%	48.5%	227.6%	137.8%	261.6%	21.0%	5.7%	8.6%	2.3%	10.9%	-9.0%	-45.3%	123.5%	6.7%
Tencent	-41.6%	21.1%	228.4%	54.7%	79.6%	75.6%	3.7%	23.6%	14.6%	11.7%	6.4%	12.0%	-48.0%	31.4%	35.6%	11.3%
Baidu	-39.6%	17.7%	57.1%	12.4%	73.4%	-9.1%	-18.7%	35.2%	-15.9%	10.3%	15.4%	20.3%	-28.1%	11.8%	9.1%	8.7%
Total	-4.3%	-9.0%	-3.6%	9.6%	23.3%	29.0%	17.2%	10.9%	9.0%	7.9%	8.7%	14.1%	16.6%	-1.6%	19.4%	10.0%
Cap. intensity (%)																
Total US	12.6%	11.4%	12.2%	12.9%	13.9%	13.3%	13.0%	12.8%	13.7%	12.9%	12.7%	13.1%	13.6%	12.3%	13.2%	13.1%
Google	9.0%	9.2%	10.5%	14.0%	13.2%	12.8%	12.8%	12.6%	12.7%	12.2%	12.2%	12.7%	11.1%	10.7%	12.8%	12.4%
Microsoft	12.5%	15.9%	19.6%	17.0%	17.6%	17.4%	17.1%	16.7%	16.7%	16.5%	16.2%	16.0%	12.1%	16.3%	17.2%	16.3%
Amazon	11.2%	8.5%	8.7%	8.6%	10.1%	9.3%	9.2%	9.4%	10.5%	9.3%	9.4%	10.4%	12.4%	9.2%	9.5%	9.9%
Meta	23.9%	19.4%	19.2%	21.6%	23.3%	22.2%	21.8%	20.9%	22.7%	21.7%	21.3%	20.9%	26.9%	21.0%	22.0%	21.6%
Oracle	21.2%	13.8%	10.6%	16.8%	17.3%	16.6%	14.8%	14.9%	14.9%	14.4%	13.5%	13.2%	14.5%	15.6%	15.9%	14.0%
Total China	2.1%	2.9%	3.8%	4.3%	4.5%	5.2%	5.6%	5.0%	4.4%	5.2%	5.4%	5.1%	4.2%	3.3%	5.1%	5.1%
Alibaba	1.2%	2.5%	1.8%	3.3%	3.8%	5.7%	6.0%	3.8%	3.7%	5.7%	5.7%	3.8%	4.4%	2.3%	4.8%	4.7%
Tencent	2.9%	2.6%	5.1%	5.6%	5.0%	4.2%	4.7%	6.3%	5.2%	4.2%	4.6%	6.4%	3.3%	4.1%	5.1%	5.1%
Baidu	4.2%	7.7%	10.2%	6.3%	6.9%	6.6%	7.5%	7.6%	5.2%	6.6%	7.8%	8.3%	6.9%	7.1%	7.2%	7.0%
Total	10.9%	10.0%	11.0%	11.6%	12.4%	12.0%	11.9%	11.6%	12.2%	11.7%	11.6%	11.9%	12.1%	10.9%	12.0%	11.9%

Source: Bloomberg, company reports

Auto: intact L-T uptrend despite N-T correction

We remain bullish on auto semis on continued conviction regarding secular semis content growth trends related to electric vehicle (EV) adoption and advanced driver-assistance system (ADAS) proliferation. Our Global Team expects the auto semis market to still grow by 4% YoY in 2024 to US$67bn, despite the recent auto/EV demand slowdown (tied to macro headwinds, namely higher interest rates, deterring buyers).
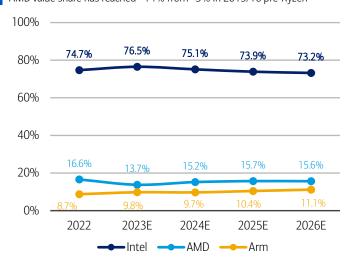
However, we are confident that even in a down-SAAR environment (S&P forecasts auto production down 0.3% YoY in CY24), the semis content gains from EV/ADAS adoption (semis $ content per vehicle +5% YoY in 2024E) will allow for continued positive auto semis growth.

Arm-based PC one of emerging drivers

Arm-based PC has been gaining share rapidly since 2020, mainly thanks to the adoption of in-house M Series by Apple, which manifests the benefit vs. x86 structure, including lower power consumption, optimized performance, etc. While we note the market remains dominated by a captive player (Apple), there are non-captive vendors, including MediaTek, Qualcomm, and NVIDIA, taking part as well. In 2023, our Global Team expects Arm PC MPU value/unit share to reach 10%/11% and sees path towards 11%/13% by 2026. For TSMC, we believe the ongoing Arm-based PC uptrend should be positive, in terms of indirect global share gains and technology leadership in the non-Intel side.

Exhibit 7: PC microprocessor (MPU) value share
AMD value share has reached ~14% from <5% in 2015/16 pre-Ryzen

Source: BofA Global Research estimates, Mercury Research
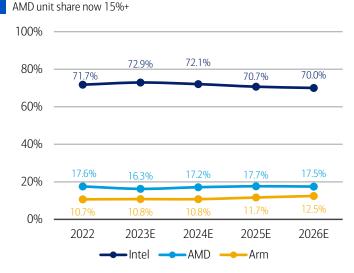
BofA GLOBAL RESEARCH

Exhibit 8: PC microprocessor (MPU) unit share
AMD unit share now 15%+

Source: BofA Global Research estimates, Mercury Research

BofA GLOBAL RESEARCH
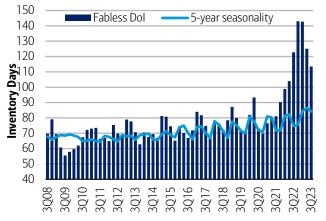
Inventory concerns largely over across most applications

The inventory levels for the majority of end-applications got healthier exiting 3Q23, backed by which we observe that the key semis players in Greater China have been gradually firming up on demand outlook into 2024 despite continuous macro uncertainties. Nevertheless, we notice that most firms still take a relatively cautious view on inventory replenishments (especially entering into the low season 1Q). It leads to low demand visibility for 2024 and thus still no medium- to long-term restocking plans by key chipmakers. The inventory level is expected to lower sequentially in 4Q23/1Q24. Amid this setup, we are positively biased on demand pick-up from 2Q24.

Exhibit 9: Fabless DoI vs. 5-year seasonality, 3Q08-3Q23
Fabless DoI was 29 days above the seasonal level in 3Q23

Source: BofA Global Research, company data, Bloomberg

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Exhibit 10: Foundry DoI vs. 5-year seasonality, 3Q08-3Q23
Foundry DoI was 34 days above the seasonal level in 3Q23

Source: BofA Global Research, company data, Bloomberg
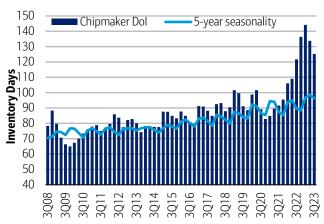
BofA GLOBAL RESEARCH

Exhibit 11: Chipmaker DoI vs. 5-year seasonality, 3Q08-3Q23
Chipmakers' DoI trended 29 days above the seasonal level in 3Q23

Source: BofA Global Research, company data, Bloomberg
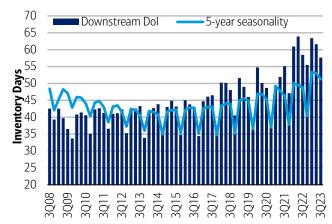
BofA GLOBAL RESEARCH

Exhibit 12: Downstream DoI vs. 5-year seasonality, 3Q08-3Q23
Downstream DoI was 6 days above the seasonal level in 3Q23

Source: BofA Global Research, company data, Bloomberg

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S/D – high exposure in outperforming nodes

As updated in our [Foundry S/D Monitor](#), within the foundry sub-sector, we expect leading-edge node foundry to outperform mature node in 2024, in view of the better supply/demand landscape (less competition and structural AI/HPC demand).

S/D outlook summary for TSMC's major nodes

As shown in Exhibit 13, TSMC's major revenue contribution in 2024 will likely come from 3nm and 4-5nm (combined 51% revenue exposure), where we expect to see a favorable S/D, thanks to solid migration demand in both smartphone and HPC applications, as well as booming AI-related demand. 6-7nm (15% revenue exposure) will remain slow in 2024, while 12-20nm and 22-32nm (combined 18% revenue exposure) will likely see a healthy S/D of ~90%.

Exhibit 13: TSMC's revenue exposure vs. foundry S/D conditions by node, 2023-25E
Based on our estimates, TSMC has ~70% revenue exposure in the nodes with tight or healthier S/D conditions in 2024

Nodes	TSMC 2023E revenue mix	Foundry 2023E S/D	S/D condition into 2023E	TSMC 2024E revenue mix	Foundry 2024E S/D	S/D condition into 2024E	TSMC 2025E revenue mix	Foundry 2025E S/D	S/D condition into 2025E
2nm							2%	27%	Ramping
3nm	5%	28%	Ramping	20%	80%	Ramping	26%	95%	Tight
4-5nm	34%	90%	Healthy	31%	97%	Tight	27%	102%	Tight
6-7nm	18%	70%	Loosen	15%	75%	Improve	14%	88%	Healthy
8-11nm	0%	58%	Loosen	0%	67%	Improve	0%	76%	Improve
12-20nm	11%	80%	Loosen	9%	89%	Healthy	8%	92%	Healthy
22-32nm	11%	87%	Healthy	9%	91%	Healthy	8%	88%	Healthy
40-45nm	6%	81%	Loosen	5%	82%	Loose	5%	82%	Loose
55-65nm	6%	72%	Loosen	5%	81%	Improve	4%	79%	Loose
80-90nm	1%	74%	Loosen	1%	76%	Loose	1%	71%	Loose
8"	7%	76%	Loosen	6%	77%	Loose	5%	81%	Improve

Source: BofA Global Research estimates, company data

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3nm – strong ramps in 2024/25E; 2nm – start with Apple AP in 2025E
Apple migrated its smartphone AP and PC/NB chipsets to 3nm in 2H23, with solid chip performance so far reaffirming TSMC's reliable track record into a new node. Into 2024, MediaTek disclosed that its new-gen flagship smartphone SoC to be launched by end-2024 will be based on TSMC 3nm node. On top of MediaTek, we continue to expect Qualcomm and AMD to also adopt 3nm process on their new-gen SoC and CPU/GPU platforms from 2H24, respectively. Fueled by the strong generative AI demand, NVIDIA will likely adopt 3nm on B100 datacenter GPU by end-2024, earlier than previous Street expectations of 2025. We estimate the 3nm foundry S/D ratio to rise to 80%/95% in 2024/25, from 28% in 2023 initially, thanks to strong HPC/smartphone product ramps along with AI megatrend. We estimate the 3nm foundry S/D ratio to rise to 80%/95% in 2024/25, from 28% in 2023, thanks to strong HPC/smartphone product ramps along with AI megatrend. On a scenario that Intel outsources 3nm CPU tiles of Arrow/Lunar to TSMC, then the 3nm foundry S/D ratio could rise to 81%/98% in 2024/25.
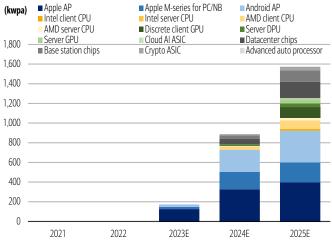
For 2nm ramp from 2025, we now expect Apple to be the only 2nm customer with initial contribution in 2025 and key products being 2nm AP for new-gen iPhone's Pro models.

Exhibit 14: 3nm foundry demand breakdown, 2021-25E
Steep 3nm ramp in 2024-25E with key customers' migrations
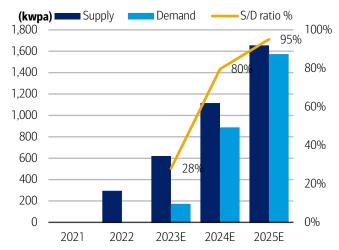
Source: BofA Global Research estimates, TechInsights, Gartner, IDC, Trendforce, company data
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**Exhibit 15: 3nm foundry supply-demand situation, 2021-25E**
We expect 3nm S/D ratio to start at 28% in 2023 and rise to 95% in 2025

Source: BofA Global Research estimates, TechInsights, Gartner, IDC, Trendforce, company data
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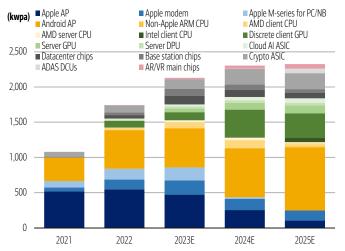
5nm – healthy to tight S/D supported by gradual migration and new adoptions

The 5nm family S/D has held relatively well during the demand downturn, primarily supported by 1) the gradual migration of Android AP and gaming GPU; 2) booming AI GPU demand; and 3) new adoptions by Intel Meteor Lake graphic tile, AI ASIC, and other second-wave chipsets. In addition, as a majority of 5nm foundry tools can be shared with 3nm process, we also anticipate some conversions in 2025 when 3nm continues the strong ramp, which is also supportive to the industry 5nm S/D. We expect the 4-5nm foundry S/D to rebound to 97%/102% in 2024/25, from the 90% trough in 2023.

Exhibit 16: 4-5nm foundry demand breakdown, 2021-25E
We expect second-wave applications to support 4-5nm demand in 2024-25

Source: BofA Global Research estimates, TechInsights, Gartner, IDC, Trendforce, company data
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Exhibit 17: 4-5nm foundry supply-demand situation, 2021-25E
We estimate 4-5nm S/D ratios at 97%/102% in 2024/25

Source: BofA Global Research estimates, TechInsights, Gartner, IDC, Trendforce, company data
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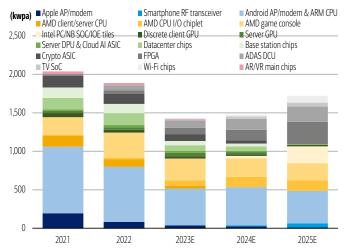
7nm – relatively muted outlook among advanced nodes

7nm has been one of the weaker areas since 2023, due to the high exposure to PC/smartphone/consumer end-markets that have been impacted more by weak macro. Into 2024, we see selective migrations from 1xnm, such as CPU I/O chiplet, FPGA, ADAS DCU, etc., but the volume is likely not big enough to lift the 7nm S/D ratio back to 80%+. More big-volume new adoptions of 7nm family could be RF mixed-signal, Wi-Fi 7 chipsets, and FPGA, but likely to contribute more from 2025. We now expect the 6-7nm foundry S/D to recover to 75%/88% in 2024/25, from 70% in 2023.

Exhibit 18: 6-7nm foundry demand breakdown, 2021-25E
We expect a later recovery in 6-7nm demand than 3/5nm families
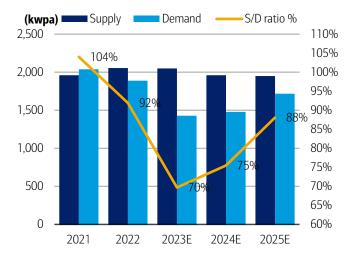
Source: BofA Global Research estimates, TechInsights, Gartner, IDC, Trendforce, company data

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Exhibit 19: 6-7nm foundry supply-demand situation, 2021-25E
We expect 6-7nm S/D ratios to be 75%/88% in 2024/25

Source: BofA Global Research estimates, TechInsights, Gartner, IDC, Trendforce, company data
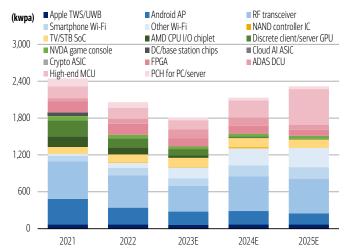
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12-16nm – recovery in 2024 supported by smartphone recovery

12-16nm demand dropped by double-digit % YoY in both 2022 and 2023, based on our estimates, mainly due to the slow smartphone-related demand (Android AP, RF transceiver). Into 2024-25E, driven mainly by likely smartphone end-demand normalization and ongoing technology migration in Wi-Fi, MCU, etc., we expect the 12-16nm foundry S/D to recover to 89%/92% healthy levels in 2024/25 from 80% in 2023E.

Exhibit 20: 12-16nm foundry demand breakdown, 2021-25E
Key demand drivers in 2024/25 could be RF, Wi-Fi, MCU
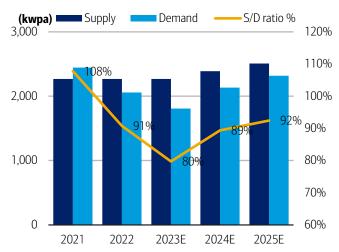
Source: BofA Global Research estimates, TechInsights, Gartner, IDC, Trendforce, company data

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Exhibit 21: 12-16nm foundry supply-demand situation, 2021-25E
We expect 12-16nm S/D ratios to be 89%/92% in 2024/25

Source: BofA Global Research estimates, TechInsights, Gartner, IDC, Trendforce, company data

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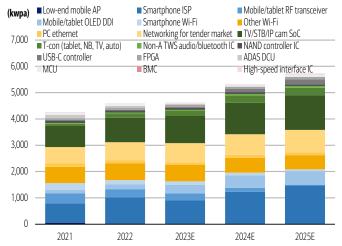
28nm – resiliency continues despite ongoing capacity expansions

In the mature 12" space, the 28nm family's S/D has remained at healthy levels (87% in 2023E) even after several rounds of overall order corrections, which we attribute to 1) migration from 40nm for ISP, MCU, smartphone/tablet OLED DDI, T-con; and 2) increasing IDM outsourcing trend. Capacity-wise, we expect 9-11% YoY increases per annum over 2023-25, with major foundries' expansion plans (e.g., UMC Tainan Fab 12A P6/Singapore Fab 12i, SMIC Beijing/Shenzhen fabs, TSMC Kumamoto fab, etc.). Despite the continuous supply increases, our bottom-up analyses suggest the 28nm family S/D to remain healthy at 91%/88% in 2024/25, on migration and demand recovery factors.

Exhibit 22: 22-32nm foundry demand breakdown, 2021-25E
We expect 22-32nm demand to be on an uptrend in 2024-25
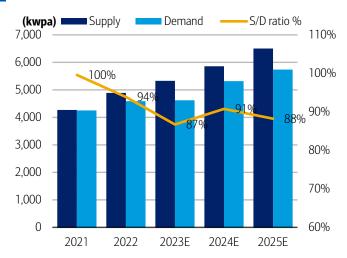
Source: BofA Global Research estimates, TechInsights, Gartner, IDC, Trendforce, company data
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Exhibit 23: 22-32nm foundry supply-demand situation, 2021-25E
We estimate 22-32nm S/D ratios at 91%/88% in 2024/25

Source: BofA Global Research estimates, TechInsights, Gartner, IDC, Trendforce, company data
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Competition – TSMC leadership continues

New leading-edge tech focus: backside power delivery

GAA has been the foundry industry's focus in the sub-3nm era and is key to winning in the next 5-10 years, which allows node migration beyond FinFET to improve performance, energy consumption, and form factor of a chip. Since 2023, key players in the leading-edge node area, TSMC, Samsung, and Intel, have expressed their intent to implement backside power delivery (BPD) from N2, aiming to further enhance transistor performance, reduce power consumptions, and eliminate potential interference between data and power connections.
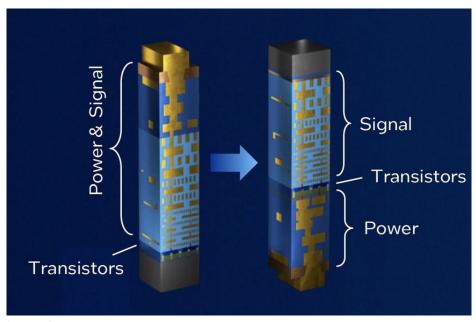
Brief introduction of BPD

BPD is an innovative method in semiconductor where the power supply lines are strategically positioned on the back side of a semiconductor chip (or IC), as opposed to the conventional placement on the frontside. The key advantages include 1) higher logic density due to the relocation of power supply lines freeing up more space for data interconnects; 2) optimized power and performance; 3) less routing congestions; and 4) cost efficiency (when technology is mature). Applied Materials estimates 20-30% cell area reduction with BPD.

Exhibit 24: Comparison of traditional frontside power delivery and new backside power delivery (BPD)
Backside power delivery refers to the technique of routing power supply lines on the backside of transistors
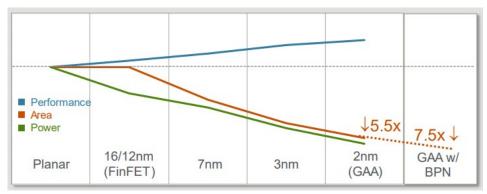
Source: Intel

Exhibit 25: Performance, power, and area (PPA) comparison for key semi process nodes
GAA with BPD will likely offer 20-30% further cell area reduction vs GAA without BPD process

Source: Applied Materials
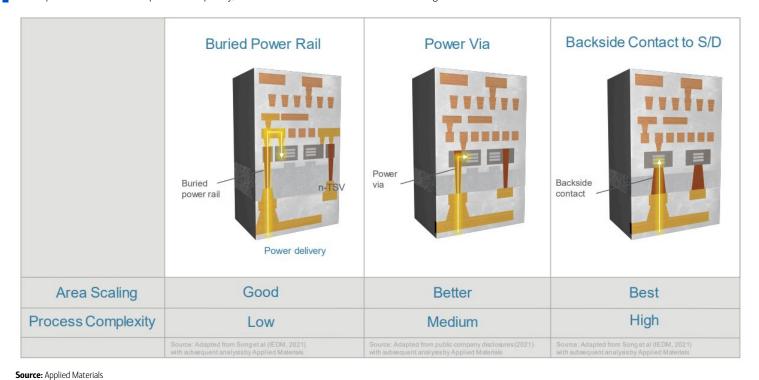
There are three major BPD schemes currently (Exhibit 26), including buried power rail, PowerVia (Intel), and backside contact to source/drain. They organize the power supply in different ways to make semiconductor chips smaller/better. Buried power rail embeds power distribution lines beneath the active device layer. It can minimize the resistive and inductive parasitic, to enhance electrical performance of chips. PowerVia, is a proprietary technology by Intel, which relocates power delivery network to the backside of chips. It can thus allow less resistive power connections and improve efficiency. Backside contact to source/drain involves creating electrical contacts on the backside of semiconductor that directly connects to source and drain terminal of a transistor. While all the three schemes aim to optimize power delivery and chip performance, the implementation complexity, impact on performance, and compatibility with existing processes are different. The choice between these technologies are subject to specific requirements of semiconductors.

Exhibit 26: Comparison of three proposed BPD approaches
Buried power rail is with lower process complexity, while PowerVia can achieve better area scaling

	Buried Power Rail	Power Via	Backside Contact to S/D
Area Scaling	Good	Better	Best
Process Complexity	Low	Medium	High
	Source: Adapted from Song et al (IEDM, 2021) with subsequent analysis by Applied Materials	Source: Adapted from public company disclosures (2021) with subsequent analysis by Applied Materials	Source: Adapted from Song et al (IEDM, 2021) with subsequent analysis by Applied Materials

Source: Applied Materials

BPD progress of TSMC, Samsung, and Intel

TSMC

Based on our understanding, TSMC aims to adopt the buried power rail approach in 2026, on its 2nd-gen 2nm process, N2P. This timeline would put TSMC around two years behind Intel when it comes to BPD production, assuming Intel will be on time in 2024 to start 20A process with BPD technology. According to TSMC, its 2nm with the backside power rail solution will provide 10-12% additional speed gain, and 10-15% larger density boost on top of the baseline technology.

Exhibit 27: TSMC leading-edge node roadmap
TSMC aims to adopt BPD in N2P process, which will be available in 2H25 with production starting 2026

Production	2018	2019	2020	2021	2022	2023	2024	2025	2026
High-end (Premium mobile, HPC, AI, gaming, ADAS)	N7	N7+	N5	N5P N7A	N4	N3 N4P/N4X	N3E N5A	N2 N3P/N3X	N2P/N2X N3A
Mainstream (Mid/low-end mobile, consumer, networking)	12FFC		12FFC+ 16FFC+	N6			N4P		N3P
New tech adoption		EUV						GAA	GAA with BPD

Source: Company data, BofA Global Research

Samsung

Samsung disclosed the metrics of its new BPD method in Aug 2023 – capable to reduce the chip area by 14.8% and the wire length by 9.2%, resulting in an overall increment in performance and a decreased resistance. However, the firm has not released a specific timeline for the adoption of BPD yet.

Intel

Intel is the most-aggressive one in the BPD space. The company introduced its BPD technology, PowerVia, in July 2021, which is scheduled to be manufacturing-ready in 2024, with the first PowerVia-embedded node being Intel 20A. According to Intel, the BPD solution can bring higher performance and lower cost, but key risks could be from 1) yield; 2) reliability; 3) thermal dissipation; and 4) debug capability.

Advanced packaging remains in focus in AI era

The semis industry has been aware of the slowdown of Moore's Law economically and technologically, given increasing challenges and difficulties involved in wafer fabrication with node advancement. Amid this environment, advanced packaging has proven to be one of the major ways to enhance overall chip performance and product quality, beyond geometric scaling on transistors, with CoWoS adoption by NVIDIA AI GPUs being the most-significant example. In our view, the front-end wafer fabrication (i.e., node migration) remains the foundation for leadership, while advanced packaging could further enhance the competitiveness, for both foundry and end-customers.

Based on our bottom-up analyses of foundry S/D, we estimate the advanced packaging TAM (combining CoWoS, InFO, SoIC) to be US$6.2/7.5/9.3bn in 2023/24/25, up 18%/20%/24% YoY (Exhibit 28), where TSMC will maintain high market shares even with outsourcing to OSATs. Based on our understanding, InFO is mainly adopted by Apple while SoIC is mainly adopted by AMD now, while CoWoS has been under the spotlight with widening customer base (Exhibit 29). Specifically, we assume the chipsets below adopt CoWoS solutions.

- 100% of (1) 3/5/7nm NVDA/AMD server GPU, (2) 3/5/7/16nm Amazon Graviton CPU and Inferentia/Trainium ASIC, (3) 7nm NVDA crypto GPU, (4) 5/7/16nm Google TPU, (5) 7/16nm FPGA from fabless

- 80% of 3nm AI ASIC from AI start-ups

- 70% of 5/7/16nm AI ASIC from AI start-ups

- 60% of 3nm server/datacenter/base station high-end chips

- 50% of (1) 5/7/16/28nm ADAS DCU, and (2) 28nm FPGA from fabless

- 20% of (1) 5/7/16nm server/datacenter/base station high-end chips, and (2) 5/7/16nm NVDA/AMD client GPU

- 5% of 3/5/7nm AMD client/server CPU

Exhibit 28: Advanced packaging TAM, 2018-25E
Based on our assumptions, the advanced packaging TAM would likely reach US$9bn by 2025, and TSMC will get a lion's share
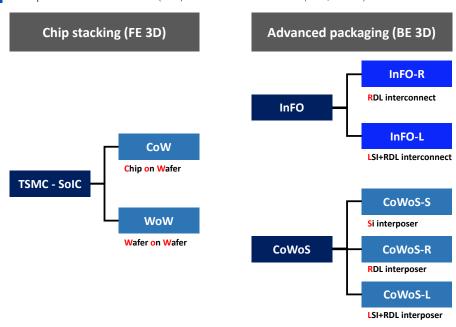
Source: Company data, BofA Global Research estimates

Exhibit 29: TSMC 3DFabric solutions
TSMC provides both front-end 3D (SoIC) and back-end 3D solutions (InFO, CoWoS)

Source: TSMC

Exhibit 30: Overview of TSMC's advanced packaging techniques
SoIC for 5nm is in production in 2023; more and more CoWoS adoptions led by NVDA GPU

Technique	Intro	Advantage	Disadvantage	Application	Timeline	Comp
3D IC						
SoIC - CoW	Integration of dies with different and/or same size and process node used	1. Enable hetero- and/or homogeneous integration at chip level (chiplet) 2. Scalability for chip I/O to reach higher density die level interconnect	1. A lower level of density vs WoW if with the same yield/output 2. Likely less efficient from the perspective cost/time needed for interconnect	AMD 3D V-Cache	In MP for 5nm	X-Cube (Samsung), Foveros (Intel)
SoIC - WoW	Wafer stacking process via bond pitch and this TSV	1. Enable hetero- and/or homogeneous integration at wafer level 2. Enable minimum parasitic to reach better performance with smaller form factor	1. High yield at wafer level is a prerequisite 2. Same die size of design/application is required	Crypto currency mining ASIC	In MP for 5nm	
2.5D IC						
CoWoS	Integrated advanced process logic IC and HBM / HBM2 in a single chip	1. Help to integrate high bandwidth memory 2. Enlarged reticle size for litho/patterning	1. High costs for high-end CoWoS-L 2. Need substrate vendors' supports for big-sized substrates	AI/HPC	In MP	I-Cube (Samsung)
InFO	Wafer level packaging, including InFO-PoP, InFO_oS, InFO_MS, InFO_AIP, etc	1. Smaller form factor, higher density/interconnect vs traditional type of packaging 2. More cost competitive vs CoWoS	1. Still a lower level of density vs CoWoS 2. Still expensive for some smartphone customers	Mobile processor PC processor	In MP	
CoWoS_S	Standard type of CoWoS, use Si interposer to connect dies	1. Relatively more stable output after years of MP 2. Higher density vs InFO, more suitable for HPC	1. Higher cost vs CoWoS_R given the adoption of Si interposer 2. Not that profitable if want to enlarge the reticle size	NVIDIA GPU Xilinx FPGA	In MP	
CoWoS_R	CoWoS with RDL interposer	1. RDL interposer is cheaper vs Si interposer 2. RDL interposer is also mechanically more flexible	1. May not be the best fit for HPC products that require ultra-high computing power	AMD CPU Amazon ASIC	In MP	
CoWoS_L	CoWoS that adopts LSI to connect dies	1. Combines the merits of CoWoS_S and InFO with better flexibility in interposer 2. Bigger reticle size to support top-spec AI/HPC chips	1. Requires the help from big-sized substrate 2. Less stable output and thus with high costs		After 2022	EMIB (Intel; similar to CoWoS LSI)
InFO_R	Basic version of InFO to enlarge the packaging area available	1. Better yield and delivery after years of MP 2. Doesn't need to use substrate unless additionally asked to	1. May be a better fit in mobile device (vs HPC), but still costly to some mid/low end models	iPhone processor	In MP	
InFO_L	Applies LSI to InFO_R for connecting dies	1. Adopts LSI which is smaller vs Si interposer 2. Supports high bandwidth integration	1. Still relatively lower density vs CoWoS	Apple's M1/M2 Ultra	In MP	

Source: BofA Global Research, company data

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Exhibit 31: TSMC, Intel and Samsung's 2.5D/3D advanced packaging solutions
Smartphone, HPC, FPGA, and wearables are the major end-applications adopting 2.5D/3D packaging

	TSMC		Intel		Samsung	
	AP technology	Applications	AP technology	Applications	AP technology	Applications
2.5D	CoWoS InFO	High-end smartphone, FPGA, HPC	EMIB	HPC	I-Cube	Wearables, smartphone
3D	SoIC	HPC, wearables	Foveros Hybrid bonding	HPC	X-Cube3D	HPC, wearables, smartphone

Source: Company data, BofA Global Research

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Exhibit 32: Advanced packaging roadmap by key supplier, key technology and key product
Foundries in leading-edge space all have their own technologies in advanced packaging

TSMC Gen-1 CoWoS
Xilinx 28nm Virtex-7 FPGA (7V2000T/7V580T)
first 2.5D TSV

TSMC Gen-1 CoWoS
HiSilicon 16nm Kunpeng server SoC (Hi1616)

TSMC Gen-2 CoWoS
Xilinx 20nm Virtex UltraScale FPGA (XCVU440)
bigger Si interposer

TSMC Gen-3 CoWoS
Nvidia 16nm Datacenter GPU (P100)
Xilinx 16nm Virtex UltraScale+ FPGAs
CoWoS with Samsung HBM2

TSMC Gen-3 CoWoS
Google TPU v2
Nvidia 12nm Datacenter GPU (V100)
NEC 16nm Vector Engine Processor

TSMC Gen-3 CoWoS
Fujitsu 7nm CPU (A64FX)
Google 16nm TPU v3
Broadcom 16nm switch SoC (Jericho 2)

TSMC Gen-4 CoWoS
AMD 7nm GPU (Vega)
Habana 16nm AI training ASIC (Gaudi)
bigger interposer + More HBM2

TSMC Gen-4 CoWoS
Nvidia 7nm Datacenter GPU (A100)
Amazon AI training ASIC (Trainium)
Xilinx 7nm Virtex UltraScale+ FPGAs
some already using HBM2E

TSMC Gen-5 CoWoS
AMD 6nm datacenter GPU (Aldebaran)
Google 7nm TPU v4
bigger interposer + HBM2E

TSMC Gen-5 CoWoS
Nvidia 5 nm Datacenter GPU (H100)
Habana 7nm AI training ASIC (Gaudi 2)
Amazon AI inferencing ASIC (Inferentia 2)
some already using HBM3

TSMC Gen-6 CoWoS
Google TPU v5e
Microsoft 5nm Maia 100 AI Accelerator
Amazon AI training ASIC (Trainium 2)
bigger interposer + HBM2E/3

TSMC Gen-6 CoWoS
(E) Nvidia 3 nm Datacenter GPU (B100)
(E) Habana 5nm AI training ASIC (Gaudi 3)
(E) Google TPU v5
bigger interposer + HBM2E/3

TSMC InFO
Apple 16nm AP (A10)

TSMC InFO
Apple 10nm AP (A11)

TSMC InFO
Apple 7nm AP (A12)

TSMC InFO
Apple 7nm AP (A13)

TSMC InFO
Apple 5nm AP (A14)

TSMC InFO
Apple 5nm AP (A15)

TSMC InFO
Apple 5nm PC SoC (M1 Ultra)
Apple 4nm AP (A16)

TSMC InFO
Apple 5nm PC SoC (M2 Ultra)
Apple 3nm AP (A17 Pro)

TSMC InFO
(E) Apple 3nm PC SoC (M3 Ultra)
(E) Apple 3nm AP (A18 series)

TSMC SoIC + CoWoS
AMD 7nm PC/datacenter CPU stacked 3D V-Cache
hybrid bonding

TSMC SoIC + CoWoS
AMD 5nm PC/datacenter CPU stacked 3D V-Cache
AMD 5nm accelerator (MI300)
hybrid bonding

TSMC SoIC + CoWoS
hybrid bonding

UMC interposer + Hynix HBM
AMD 28nm GPU (Fiji)
first HBM adoption

Samsung I-Cube 2
2.5D packaging; ready for usage

Samsung I-Cube 2
Baidu 14nm AI chip (Kunlun)

Samsung I-Cube 4

Samsung I-Cube 8
8x HBMs

Samsung X-Cube
3D packaging; hybrid bonding

Intel
Intel Xeon Phi CPU (Knights Landing)
Multi-Channel DRAM (3D-stacked)

Intel EMIB
Intel 14nm FPGA (Stratix 10)
first 2.5D embedded bridge

Intel EMIB
Intel 14+nm CPU (Kaby Lake G)

Intel EMIB
Intel 10nm FPGA (Agilex)

Intel EMIB
Intel 7nm Xeon CPU (Sapphire Rapids)

Intel Foveros
Intel 10nm hybrid CPU (Lakefield)
3D stacking

Intel Foveros + EMIB
Intel 7nm GPU (Ponte Vecchio)
EMIB interconnects HBM2 and I/O with GPU

Intel Foveros Omni
Intel 4nm Meteor Lake CPU
enhanced version

Intel Foveros Omni
(E) Intel Arrow/Lunar Lake CPUs
enhanced version

Intel Foveros Direct
hybrid bonding

2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

Source: Company data, BofA Global Research

Competition landscape – we believe TSMC will lead

TSMC chose to be a late-adopter in both GAA and BPD areas, which we believe is mainly due to considerations on cost, yield rate, and scaling stability. Indeed, we've noticed Samsung's and Intel's aggressiveness in process roadmap to compete with TSMC, through earlier GAA or BPD adoption. That said, we believe TSMC's strong execution – better yield, steadier delivery, and better support/services to customers – and neutral stance as a pure-play foundry will still be moating its leadership in the foundry space. In addition, TSMC's comprehensive offerings in advanced packaging (InFO, CoWoS, SoIC) are likely to further solidify its technology leadership in the advanced node space.

2024: to outpace industry in recovery
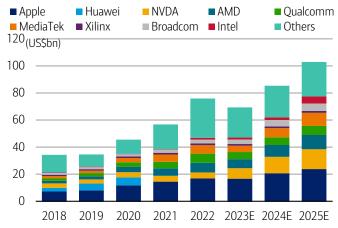
Cyclical recovery + structural growth drivers

Thanks to 1) end-demand growth likely in most of the segments with healthier inventory levels exiting 2023, such as smartphone; 2) AI-related new demand; and 3) replacement cycle for select end-applications like PC and server, our Global Team's estimates on TSMC's key clients into 2024 are generally positive growth.

By client, we expect TSMC's revenue mix from NVIDIA, MediaTek, Broadcom, and Intel to increase in 2024, fueled by their node migrations and/or increasing projects. We expect Apple's and AMD's revenue contribution % for TSMC to remain steady at 24% and 10%, respectively, in 2024. As for Qualcomm, we expect its revenue mix to slightly decline to 7% in 2024, which we deem as normal volatility as it tends to maintain multiple foundry sources in advanced nodes for cost reduction and risk management.

Exhibit 33: Revenue mix by customer
TSMC's 2024 sales to be mainly supported by major customers' growth
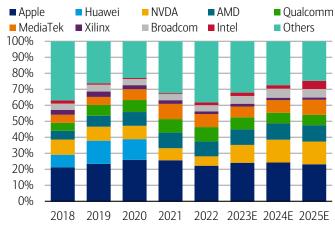
Source: BofA Global Research estimates, company data

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Exhibit 34: Revenue mix % by customer
Major customers contribute 70%+ of total revenue for TSMC

Source: BofA Global Research estimates, company data

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Exhibit 35: Incremental revenue from key customers
We expect incremental revenue across all key customers in 2024

Source: BofA Global Research estimates, company data

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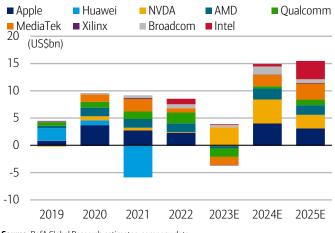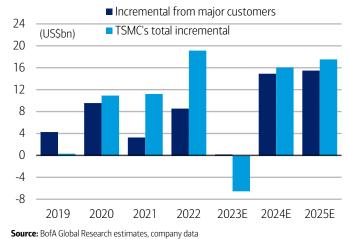
Exhibit 36: Incremental revenue - from key customers vs overall
Key clients' incremental revenue to be supportive to TSMC 2024 sales rebound

Source: BofA Global Research estimates, company data

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Exhibit 37: 2023E customer revenue mix
We expect NVDA/AMD and QCOM/MTK to contribute 10-11% and 7-8% revenue in 2023

Source: BofA Global Research estimates, company data

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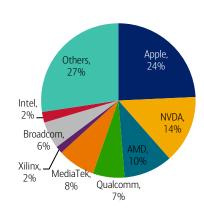
Exhibit 38: 2024E customer revenue mix
We expect NVDA's revenue contribution to expand to 14% in 2024

Source: BofA Global Research estimates, company data
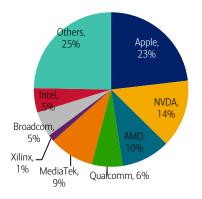
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Exhibit 39: 2025E customer revenue mix
We expect Intel's revenue contribution to expand to 5% in 2025

Source: BofA Global Research estimates, company data

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Rising Intel contribution with more outsourcing

We estimate Intel's revenue contribution to TSMC will rise meaningfully to 2%/5% in 2024/25, as a base case. Our key assumptions for Intel's PC CPU orders at TSMC include:

1. 5nm graphic/6nm SOC/6nm IOE tiles of Meteor Lake, which was officially launched in Dec 2023

2. 3nm graphic/5nm IOE tiles of Lunar Lake for NB processor, which is expected to be launched in late-2024

Besides, we expect Intel to continue outsourcing existing and the successor products, including 1) Mobileye 7nm auto domain controller unit or DCU; 2) partial 1x-4xnm Wi-Fi chips/field-programmable gate array or FPGA; 3) 4-5nm datacenter GPU's computing tile and crypto application-specific integrated circuit or ASIC; 4) 6-7nm client GPU and datacenter GPU's I/O; and 5) Habana 5/7/16nm ASIC.

Furthermore, the greater upside may come from Intel's 3nm outsourcing projects in 2024/25, including CPU tiles. It could further expand revenue contribution to 3%/6% in 2024/25.

Exhibit 40: Intel's potential contribution to TSMC by node/application in 2021-25E
We now estimate Intel's revenue contribution to be 2%/5% in 2024/25
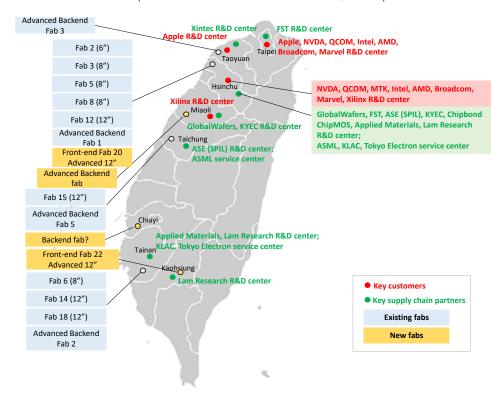
Node	Applications	Wafer volume (k wafers)					Revenue contribution (US$mn)				
		2021	2022	2023E	2024E	2025E	2021	2022	2023E	2024E	2025E
3nm											
	PC/NB CPU graphic tile				1	15				23	274
4-5nm											
	PC/NB CPU graphic tile			1	8	52			14	121	837
	PC/NB CPU IOE tile				0	6				7	89
	Datacenter GPU computing tile		1	3	3	3		9	49	48	47
	Crypto ASIC		18	11	0	0		289	178	0	0
	Habana ASIC				5	13				73	208
6-7nm											
	PC/NB CPU SOC/IOE tiles			3	33	217			40	390	2,388
	Client GPU		9	13	13	13		113	152	154	147
	Datacenter GPU I/O tile		0	0	1	1		1	6	7	7
	Mobileye auto DCU	2	47	49	56	79	20	563	586	672	868
	Habana ASIC		1	6	3	0		14	67	41	0
12-20nm											
	PC/NB/tablet Wi-Fi chips	1	2	5	8	10	5	14	31	55	63
	Habana ASIC	1	1				6	9			
22-32nm											
	PC/NB/tablet Wi-Fi chips	16	15	13	10	9	57	62	57	41	37
	Altera FPGA	52	55	58	64	71	183	222	262	258	285
40-45nm											
	PC/NB/tablet Wi-Fi chips	17	10	5	3	0	49	33	16	11	1
Total revenue contribution							**319**	**1,328**	**1,460**	**1,902**	**5,251**
TSMC revenue							56,758	75,881	69,321	85,373	102,899
Contribution % to TSMC							**1%**	**2%**	**2%**	**2%**	**5%**

Source: BofA Global Research estimates, Gartner, IDC, company data

Exhibit 41: TSMC's factory map/capacity overview and key customers/supply chain partners' locations
Taiwan is one of the most comprehensive semiconductor cluster in the world; TSMC expands in both front-end and back-end

Major TW fabs	Wafer size/nodes	Monthly capacity by end-25 (E)
Fab 2	6"	80-90k
Fab 3/5/6/8	8"	~360k
Fab 12	12" 16-40nm	150-160k
Fab 14	12" 12-20nm/ 40nm-0.13um	330-340k
Fab 15	12" 7/28nm	340-350k
Fab 18	12" 3/5nm	~240k
Fab 20 (Hsinchu)	12" 2nm	30-40k
Fab Taichung	12" 2nm	~5k
Fab 22 (Kaohsiung)	12" leading edge	n.a.

Other fabs	Wafer size/nodes	Monthly capacity by end-25 (E)
Fab 11 (US)	8"	~40k
Fab 16 (Nanjing)	12" 16/28nm	60-70k
SSMC (SG)	8"	~25k
Fab 21 (Arizona)	12" 4/3nm	20k
Fab 23 (Kumamoto)	12" 12-16nm/22-28nm	55k

Source: Company data, BofA Global Research estimates

Financial highlights

Strong 20%+ revenue growth in 2024/25E
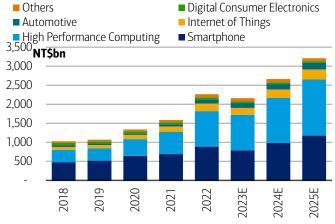
We expect TSMC to register 23%/21% revenue YoY in 2024/25, with 22%/24% earnings growth over the same period, with dilution impact on GPM along with 3/2nm capacity ramp-up largely offset by scale benefits from improving UTR.

By platform, we expect HPC to continue leading, with 25% CAGR in 2023-25E. while smartphone/IoT also generate 22%/22% CAGR, off lower bases in 2023. For automotive, we expect the platform to see 16% CAGR over the same period, partially capped by ongoing inventory correction in 1H24. We project HPC to remain as the largest revenue contributor for TSMC in 2024/25, with 44%/46% revenue exposure.

Exhibit 42: Annual revenue by platform
HPC will likely remain as a key growth contributor in 2024-25

Legend: Others, Digital Consumer Electronics, Automotive, Internet of Things, High Performance Computing, Smartphone

NT$bn

Source: BofA Global Research estimates, company data

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Exhibit 43: Annual revenue % by platform
HPC to be the largest platform in 2024-25E

Legend: Others, Digital Consumer Electronics, Automotive, Internet of Things, High Performance Computing, Smartphone

Source: BofA Global Research estimates, company data
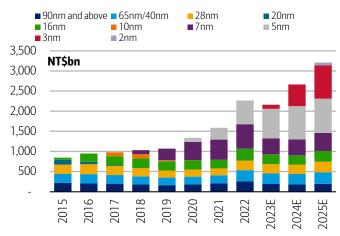
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Exhibit 44: Annual revenue by technology node
TSMC's growth ahead will be mainly powered by advanced nodes (5/3nm)

Legend: 90nm and above, 65nm/40nm, 28nm, 20nm, 16nm, 10nm, 7nm, 5nm, 3nm, 2nm

NT$bn

Source: BofA Global Research estimates, company data
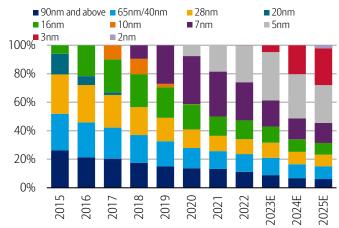
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Exhibit 45: Annual revenue % by technology node
We expect TSMC's 3nm revenue mix to be 20%/26% in 2024/25

Legend: 90nm and above, 65nm/40nm, 28nm, 20nm, 16nm, 10nm, 7nm, 5nm, 3nm, 2nm

Source: BofA Global Research estimates, company data

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Exhibit 46: Revenue by technology node
3nm to be a key driver throughout 2024

Legend: 90nm and above, 65nm/40nm, 28nm, 20nm, 16nm, 10nm, 7nm, 5nm, 3nm

NT$bn (y-axis 0 to 800)
x-axis: 1Q22, 2Q22, 3Q22, 4Q22, 1Q23, 2Q23, 3Q23, 4Q23E, 1Q24E, 2Q24E, 3Q24E, 4Q24E

Source: BofA Global Research estimates, company data

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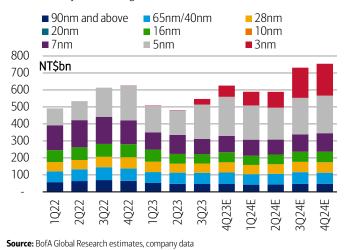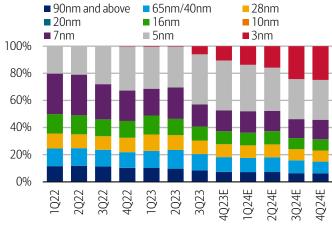
Exhibit 47: Revenue % by technology node
We expect expanding 3nm mix into 2024

Legend: 90nm and above, 65nm/40nm, 28nm, 20nm, 16nm, 10nm, 7nm, 5nm, 3nm

y-axis 0% to 100%
x-axis: 1Q22, 2Q22, 3Q22, 4Q22, 1Q23, 2Q23, 3Q23, 4Q23E, 1Q24E, 2Q24E, 3Q24E, 4Q24E

Source: BofA Global Research estimates, company data

BofA GLOBAL RESEARCH
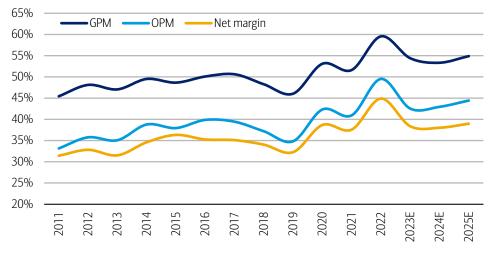
Steady GPM backed by resilient pricing /node migration

Profitability-wise, we model for 53.3%/54.9% GPM and 43.0%/44.4% OPM in 2024/25, showing modest improvement YoY. Thanks to node migration toward 3/2nm, we expect TSMC to post 15%/4% wafer blended ASP growth in 2024/25E. In our view, although there is likely to be ongoing pricing negotiations for leading edge nodes, the pricing will likely remain steadier than worried, protected by TSMC's leading industry position. As for mature nodes, the trends could be diversified – lower end/commodity processes could see soft pricing trends with low industry-wide UTR, but specialty processes could still post steady pricing with niche market exposure. Net-net, for TSMC, the major nodes that it focuses on will likely see steady pricing environment in 2024 to support the margins.

Exhibit 48: GPM/OPM/NPM trend, 2011-25E
We expect margins to remain steady in 2024-25 despite dilutions from 3nm ramp

Legend: GPM, OPM, Net margin
y-axis 20% to 65%
x-axis: 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023E, 2024E, 2025E

Source: BofA Global Research estimates, TEJ, company data

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Normalized capital intensity; rising FCF; better div. payout
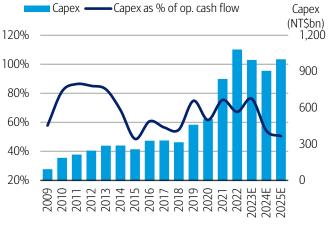
Looking forward, we project TSMC's capex to stay robust at US$29/32bn in 2024/25 vs. ~US$32bn in 2023E, mainly to address the promising 3nm demand growth and support global expansion plans (US, Japan, Germany). We expect its capital intensity to decline to 30-35% in 2024/25 on higher revenue scale, as its previous efforts pay off, and its

capex as a percent of operating cash flow to decrease to 50-55% over the same forecast period. In turn, this will trickle down to a continuously rising free cash flow per share, where we expect NT$30/38 generated in 2024/25 (vs. NT$20/12 in 2022/23E).

Exhibit 49: Capex as % of operating cash flow
We expect moderate capex decline in 2024 to US$29bn

Source: BofA Global Research estimates, company data
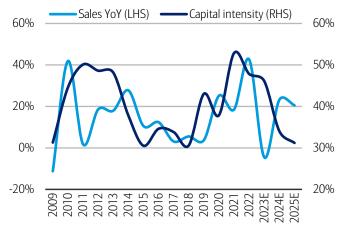
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Exhibit 50: Capital intensity vs. sales YoY
We expect capital intensity to decrease to 30-35% levels in 2024-25

Source: BofA Global Research estimates, company data
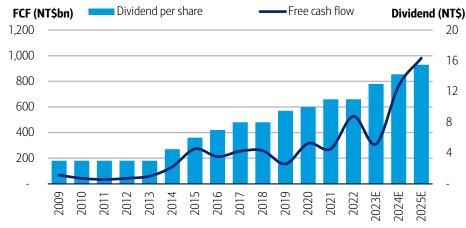
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Exhibit 51: Free cash flow (FCF) and dividend trend, 2007-24E
DPS likely on an increasing trend over 2024-25E along with FCF increases

Source: BofA Global Research estimates, TEJ, company data

BofA GLOBAL RESEARCH

4Q likely at guidance high-end; 1Q better than seasonal

TSMC will host 4Q23 earnings call on 18 Jan at 2PM HKT, in which we expect it to post 4Q23 gross margin/EPS of 53.2%/NT$8.9 (vs. consensus of 53.0%/NT$8.7), vs guidance of 51.5-53.5%.

4Q revenue came in at NT$626bn (or US$19.6bn based on average US$/NT$ at 31.8), reaching the high-end of its guidance range (US$18.8-19.6bn), up 14% QoQ and flat YoY, 2%/1% above our previous/Street expectations. With higher revenue scale in 4Q, we expect the gross margin to be at the high-end of guidance.

Into 1Q24, we expect TSMC to guide 6% QoQ revenue decline in NT$ terms or 4% in US$ terms (consensus at -7% QoQ in NT$ terms), with gross margin lowering to 51.5% level (consensus 51.0%), due to lower UTR and unfavorable FX.

Exhibit 52: 4Q23 guidance vs. BofAe vs. consensus and 1Q24 estimates

4Q revenue beat by 1-2%; we now model 6% QoQ decline in 1Q revenue in NT$ terms (or 4% US$ terms)

	4Q23			1Q24	
NT$bn; %	Guidance	BofAe	Consensus	BofAe	Consensus
Revenue	US$18.8-19.6bn on FX of 32 (or NT$602-627bn)	626 (Actual)	619	589	576
QoQ (%)	Up 10-15% QoQ in NT$	14%	13%	-6%	-7%
Gross margin (%)	51.5-53.5%	53.2%	53.0%	51.5%	51.0%
Opt margin (%)	39.5-41.5%	41.3%	41.4%	40.7%	39.9%
EPS (NT$)		8.86	8.73	8.22	7.86

Source: BofA Global Research estimates, company data, Bloomberg

Exhibit 53: Earnings estimate changes, 2023-25E

We tweak our 2023E EPS by 0.4% after factoring in 4Q actual revenue but lower our 2024E EPS by 3% to reflect lower UTR and unfavorable FX

	2023E			2024E			2025E		
NT$bn	New	Old	Diff	New	Old	Diff	New	Old	Diff
Revenue	2,162	2,152	0.5%	2,664	2,692	-1.1%	3,210	3,210	0.0%
Gross profit	1,176	1,171	0.5%	1,421	1,469	-3.3%	1,763	1,769	-0.4%
GPM	54.4%	54.4%	0.0ppt	53.3%	54.6%	-1.2ppt	54.9%	55.1%	-0.2ppt
Opt income	920	915	0.5%	1,144	1,185	-3.4%	1,426	1,426	0.0%
Opt margin	42.5%	42.5%	0.0ppt	43.0%	44.0%	-1.1ppt	44.4%	44.4%	0.0ppt
Pretax income	971	967	0.4%	1,194	1,233	-3.2%	1,474	1,474	0.0%
Pretax margin	44.9%	44.9%	0.0ppt	44.8%	45.8%	-1.0ppt	45.9%	45.9%	0.0ppt
Net income	829	826	0.4%	1,013	1,046	-3.2%	1,251	1,251	0.0%
EPS (NT$)	31.99	31.85	0.4%	39.05	40.35	-3.2%	48.25	48.25	0.0%

Source: BofA Global Research estimates

Exhibit 54: BofAe vs. consensus, 2023-25E

Our 2024/25 EPS estimates are 3%/2% ahead of consensus on better revenue assumptions

	2023E			2024E			2025E		
NT$bn	BofA	Consensus	Diff	BofA	Consensus	Diff	BofA	Consensus	Diff
Revenue	2,162	2,155	0.3%	2,664	2,631	1.2%	3,210	3,115	3.1%
Gross profit	1,176	1,172	0.4%	1,421	1,395	1.9%	1,763	1,701	3.6%
Gross margin	54.4%	54.4%	0.0ppt	53.3%	53.0%	0.3ppt	54.9%	54.6%	0.3ppt
Opt income	920	917	0.3%	1,144	1,118	2.3%	1,426	1,389	2.7%
Opt margin	42.5%	42.5%	0.0ppt	43.0%	42.5%	0.4ppt	44.4%	44.6%	-0.1ppt
Pretax income	971	968	0.3%	1,194	1,159	3.0%	1,474	1,437	2.6%
Pretax margin	44.9%	44.9%	0.0ppt	44.8%	44.0%	0.8ppt	45.9%	46.1%	-0.2ppt
Net income	829	826	0.4%	1,013	983	3.1%	1,251	1,231	1.6%
EPS (NT$)	31.99	31.85	0.4%	39.05	37.89	3.1%	48.25	47.47	1.6%

Source: BofA Global Research estimates, Bloomberg

Exhibit 55: Earnings model, 2022-25E
We now model 23% YoY revenue increase in 2024 in NT$ terms

(NT$bn, %)	1Q23	2Q23	3Q23	4Q23E	1Q24E	2Q24E	3Q24E	4Q24E	2022	2023E	2024E	2025E
Revenues	509	481	547	626	589	589	731	754	2,264	2,162	2,664	3,210
Cost of Sales	-222	-221	-250	-293	-286	-283	-333	-342	-916	-986	-1,243	-1,448
Gross Profit	287	260	297	333	304	306	398	413	1,348	1,176	1,421	1,763
Operating Expenses	-55	-58	-69	-74	-64	-63	-73	-77	-227	-257	-277	-336
Operating Income	231	202	228	258	240	244	325	336	1,121	920	1,144	1,426
Non-operating Income (Exp)	13	13	14	12	12	12	13	12	23	51	49	48
Pretax Income	244	215	242	270	252	256	338	348	1,144	971	1,194	1,474
Net tax	-37	-33	-31	-41	-38	-39	-51	-52	-127	-142	-181	-224
Net Income	207	182	211	230	213	217	287	296	1,017	829	1,013	1,251
Fully Diluted EPS - Local (NT$)	8.0	7.0	8.1	8.9	8.2	8.4	11.1	11.4	39.2	32.0	39.1	48.3
% of Revenue												
Gross Profit	56.3	54.1	54.3	53.2	51.5	52.0	54.5	54.7	59.6	54.4	53.3	54.9
Operating Expenses	-10.9	-12.1	-12.5	-11.9	-10.9	-10.7	-10.0	-10.2	-10.0	-11.9	-10.4	-10.5
Operating Income	45.5	42.0	41.7	41.3	40.7	41.4	44.5	44.5	49.5	42.5	43.0	44.4
Pretax Income	48.0	44.6	44.3	43.2	42.7	43.5	46.2	46.1	50.5	44.9	44.8	45.9
Net Income	40.7	37.8	38.6	36.7	36.2	36.8	39.2	39.2	44.9	38.4	38.0	39.0
QoQ Growth %												
Revenues	-18.7	-5.5	13.7	14.4	-5.8	-0.1	24.2	3.2				
Gross Profit	-26.4	-9.2	14.0	12.2	-8.8	0.9	30.1	3.5				
Operating Income	-28.9	-12.7	12.9	13.3	-7.3	1.6	33.6	3.2				
Net Income	-30.0	-12.2	16.1	8.9	-7.2	1.6	32.3	3.2				
YoY Growth %												
Revenues	3.6	-10.0	-10.8	0.0	15.9	22.5	33.7	20.6	42.6	-4.5	23.2	20.5
Gross Profit	4.9	-17.5	-19.9	-14.5	5.9	17.7	34.3	24.0	64.5	-12.8	20.8	24.1
Operating Income	3.3	-23.0	-26.5	-20.5	3.6	20.6	42.7	29.9	72.5	-18.0	24.4	24.7
Net Income	2.1	-23.3	-24.9	-22.4	3.0	19.2	35.9	28.9	70.4	-18.4	22.1	23.6

Source: BofA Global Research estimates, company data

Exhibit 56: Operation model, 2022-25E
We expect TSMC to see improvement in utilization rates in 2024/25

	1Q23	2Q23	3Q23	4Q23E	1Q24E	2Q24E	3Q24E	4Q24E	2022	2023E	2024E	2025E
Utilization	83%	74%	73%	76%	73%	75%	87%	86%	101%	77%	80%	86%
Shipments (12-inch equivalent, '000s)	3,227	2,916	2,902	3,054	2,912	3,007	3,481	3,527	15,253	12,099	12,927	14,994
Total revenue (NT$bn)	509	481	547	626	589	589	731	754	2,264	2,162	2,664	3,210
ASP ($)	5,181	5,376	5,954	6,433	6,487	6,277	6,731	6,855	4,986	5,737	6,594	6,839
Sequential growth (%)												
Shipments	-13%	-10%	0%	5%	-5%	3%	16%	1%	8%	-21%	7%	16%
ASP ($)	-4%	4%	11%	8%	1%	-3%	7%	2%	25%	15%	15%	4%
Revenue share by process technology												
0.11 micron and more matured nodes	8%	8%	7%	6%	6%	6%	6%	5%	10%	7%	6%	5%
90nm	2%	2%	1%	1%	1%	1%	1%	1%	2%	1%	1%	1%
65nm	6%	7%	6%	5%	5%	5%	5%	4%	5%	6%	5%	4%
40nm	7%	7%	6%	5%	5%	5%	5%	5%	8%	6%	5%	5%
28nm	12%	11%	10%	10%	9%	10%	8%	8%	10%	11%	9%	8%
16-20nm	14%	12%	10%	10%	9%	10%	8%	8%	13%	11%	9%	8%
2-10nm	51%	54%	59%	63%	64%	63%	68%	69%	53%	57%	66%	69%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Revenue percentage by platform												
Smartphone	34%	33%	39%	39%	36%	35%	38%	38%	39%	36%	37%	37%
High Performance Computing	44%	44%	42%	43%	45%	44%	45%	44%	41%	43%	44%	46%
Internet of Things	9%	8%	9%	8%	9%	9%	8%	9%	9%	8%	8%	8%
Automotive	7%	8%	5%	4%	5%	6%	5%	6%	5%	6%	5%	5%
Digital Consumer Electronics	2%	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%
Others	4%	4%	3%	4%	4%	5%	3%	2%	3%	4%	3%	2%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Revenue percentage by region												
North America	63%	66%	69%	70%	65%	67%	70%	71%	68%	67%	68%	69%
Asia Pacific	8%	8%	8%	8%	9%	9%	9%	9%	11%	8%	9%	10%
China	15%	12%	12%	11%	13%	12%	12%	11%	11%	12%	12%	12%
Europe	7%	7%	5%	5%	7%	7%	5%	5%	6%	6%	5%	5%
Japan	7%	7%	6%	6%	7%	5%	5%	5%	5%	6%	5%	4%

Source: BofA Global Research estimates, company data

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Exhibit 57: Balance sheet, 2022-25E
Despite heavy capital investment, we expect TSMC's balance sheet to remain pretty solid

(NT$bn)	1Q23	2Q23	3Q23	4Q23E	1Q24E	2Q24E	3Q24E	4Q24E	2022	2023E	2024E	2025E
Cash	1,385	1,277	1,312	1,462	1,543	1,609	1,734	1,895	1,343	1,462	1,895	2,509
Short Term Investment	204	213	240	226	233	230	231	230	219	226	230	231
Accounts receivable	148	191	223	204	206	216	231	215	231	204	215	234
Inventory	216	234	262	233	239	264	275	281	221	233	281	336
Other current assets	42	45	46	42	43	44	44	44	39	42	44	43
Current Assets	1,996	1,960	2,082	2,167	2,264	2,362	2,515	2,665	2,053	2,167	2,665	3,354
Long Term Investments	70	95	116	105	111	108	110	109	69	105	109	109
Fixed Assets	2,833	2,947	3,133	3,207	3,266	3,330	3,388	3,438	2,694	3,207	3,438	3,637
Other Assets	147	148	153	149	149	150	150	150	149	149	150	150
Long-term Assets	3,050	3,190	3,402	3,462	3,526	3,588	3,648	3,696	2,912	3,462	3,696	3,896
Total Assets	5,046	5,149	5,485	5,629	5,789	5,950	6,163	6,362	4,965	5,629	6,362	7,250
Short term loans	-	-	-	-	-	-	-	-	-	-	-	-
Notes & Accounts Payable	47	49	54	53	67	70	73	68	57	53	68	79
Current portion of long term debt	8	8	7	11	9	9	9	9	19	11	9	9
Other current Liabilities	818	754	909	927	936	936	936	936	868	927	936	946
Current Liabilities	873	811	970	991	1,011	1,015	1,018	1,013	944	991	1,013	1,033
Long term debt	855	907	937	884	896	906	906	898	839	884	898	901
Other non-current liabilities	225	226	204	231	263	342	383	460	221	231	460	522
Long-term Liabilities	1,080	1,133	1,142	1,115	1,159	1,248	1,289	1,358	1,060	1,115	1,358	1,423
Total Liabilities	1,953	1,944	2,112	2,106	2,170	2,263	2,307	2,371	2,004	2,106	2,371	2,456
Total parent shareholders' equity	3,078	3,189	3,348	3,505	3,601	3,668	3,836	3,972	2,946	3,505	3,972	4,775
Minority Interest	15	17	24	18	18	19	20	19	15	18	19	19
Total Liabilities and Equity	5,046	5,149	5,485	5,629	5,789	5,950	6,163	6,362	4,965	5,629	6,362	7,250

Source: BofA Global Research estimates, company data

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Exhibit 58: Cash flow, 2021-24E
TSMC has committed to deliver a steady dividend payout policy

(NT$bn)	1Q23	2Q23	3Q23	4Q23E	1Q24E	2Q24E	3Q24E	4Q24E	2022	2023E	2024E	2025E
Net Profit	207	182	211	230	213	217	287	296	1,017	829	1,013	1,251
Depreciation & Amortization	110	124	147	147	150	157	170	176	437	529	652	774
Change in Working Capital	76	(62)	(56)	51	5	(32)	(23)	4	(65)	9	(46)	(63)
Other adjustment	(8)	(77)	(7)	32	21	13	12	7	222	(60)	53	20
Operating Cash Flow	385	167	295	460	389	354	446	483	1,611	1,307	1,672	1,983
Capital Expenditure	(302)	(251)	(227)	(217)	(227)	(227)	(227)	(227)	(1,083)	(997)	(906)	(1,002)
Proceeds from sale of non-current assets	0	0	0	0	0	0	0	0	1	1	1	1
Acquisitions/Disposals of investments	16	(29)	(40)	24	(12)	6	(3)	2	(131)	(29)	(8)	(0)
Other investment items	14	20	24	4	(0)	(1)	(1)	1	21	62	(0)	(0)
Investing Cash Flow	(272)	(259)	(242)	(189)	(238)	(221)	(230)	(224)	(1,191)	(963)	(914)	(1,002)
Net Share issue/repurchase	-	-	-	-	-	-	-	-	-	-	-	-
Dividends paid	(71)	(71)	(71)	(71)	(78)	(78)	(91)	(91)	(285)	(285)	(337)	(370)
Change in debt	10	41	10	(50)	9	11	(0)	(8)	84	10	12	3
Other financing cash flow	(3)	4	23	-	-	-	(0)	-	1	24	(0)	(0)
Financing Cash Flow	(64)	(27)	(38)	(121)	(69)	(67)	(91)	(98)	(200)	(251)	(325)	(367)
Net Change in Cash	49	(119)	14	150	81	66	125	160	219	94	433	615
Exchange effect	(6)	10	21	-	-	-	-	-	58	25	-	-
Cash, Beginning of Year	1,343	1,385	1,277	1,312	1,462	1,543	1,609	1,734	1,065	1,343	1,462	1,895
Cash, End of Year	1,385	1,277	1,312	1,462	1,543	1,609	1,734	1,895	1,343	1,462	1,895	2,509

Source: BofA Global Research estimates, company data

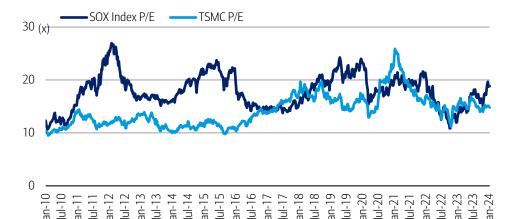# Valuation discussion

PO of NT$760 based on 18x 2H24-1H25E P/E

Our NT$760 PO is based on 18x 2H24-1H25E P/E (previously 2Q24-1Q25E), which is in line with its 5-year average. In our view, P/E valuation is appropriate for TSMC given its strong earnings growth and outstanding FCF. TSMC has been on a continuous re-rating trend since 2015, driven by technology leadership and structural positive trends, including market-share gains, IDM outsourcing, fabless share gains, and semis content increase. TSMC's leading position is reinforced by its outstanding capability in leading edge and advanced packaging, which becomes more significant in the AI era. This is likely to place TSMC further ahead of competitors and drive its earnings growth and lead to a re-rating.

We note that TSMC's forward P/E has tended to move along with SOX since 2020. SOX trades at upcycle valuation currently, while TSMC's valuation has not picked up as fast as SOX's. In this case, we believe the risk to the stock's valuation is skewed to the upside and deserves a re-rating, in view of the likely stronger growth rate in 2024 vs. the semis industry and the attractive risk-reward.

Exhibit 59: TSMC's 12-month forward P/E vs SOX's
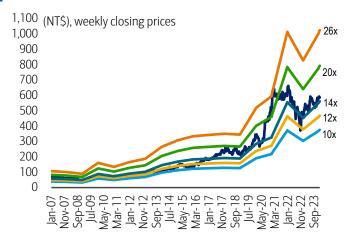Since 2020, TSMC's P/E often moved in the same direction with SOX's

Source: BofA Global Research estimates, company data, Bloomberg

Exhibit 60: 12-month forward P/E
The stock now trades at 15x 2024E P/E

Source: BofA Global Research estimates, Bloomberg

Exhibit 61: 12-month forward P/E with +2 to -2 standard deviation
Current P/E (15x) is below the average level since 2017

Avg + 2std = 21x
Avg + 1std = 19x
Avg P/E = 17x
Avg - 1std = 14x
Avg - 2std = 12x

Source: BofA Global Research estimates, Bloomberg

Exhibit 62: 12-month forward P/B
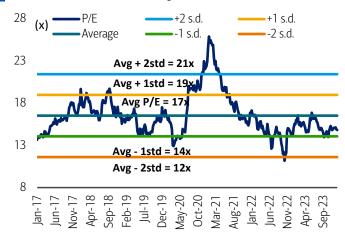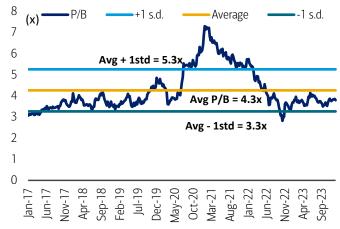The stock now trades at 3.8x 2024E P/B

Source: BofA Global Research estimates, Bloomberg

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Exhibit 63: 12-month forward P/B with +1 to -1 standard deviation
Current P/B (3.8x) is below the average level since 2017

Source: BofA Global Research estimates, Bloomberg

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Exhibit 64: Valuation comparisons
TSMC currently trades at lower P/E level vs. foundry/IDM/fabless/equipment maker companies' average levels

Ticker	Company	Share price (LC)	Rating	Mkt cap (US$mn)	EPS (LC) 2024E	2025E	PER (X) 2024E	2025E	PBR (X) 2024E	2025E	Div. yield (%) 2024E	2025E	ROE (%) 2024E	2025E	EV/EBITDA 2024E	2025E
Foundry																
2330 TT	TSMC	586	BUY	486,372	39.05	48.25	15.0	12.1	3.8	3.2	2.4	2.6	27.1	28.6	8.2	6.7
GFS US	GlobalFoundries	57.4	Neutral	31,748	2.12	2.70	27.1	21.3	2.7	2.5	0.0	0.0	10.1	12.3	12.5	10.8
981 HK	SMIC	17.1	NC	25,593	0.10	0.15	21.8	14.7	0.8	0.7	0.0	0.0	3.6	4.9	10.3	8.8
2303 TT	UMC	50.8	BUY	20,372	4.98	5.73	10.2	8.9	1.8	1.6	5.9	6.9	17.9	18.8	5.4	4.6
5347 TT	Vanguard	77.8	Neutral	4,081	4.03	6.01	19.3	12.9	3.5	3.4	5.8	7.1	17.4	26.6	8.5	7.2
1347 HK	Hua Hong	19.1	U/P	5,429	0.17	0.22	14.6	11.2	1.0	0.9	0.0	0.0	7.0	8.3	5.8	5.0
6770 TT	PSMC	28.9	U/P	3,766	-0.43	-0.02	n.m.	n.m.	1.4	1.3	0.0	0.0	-2.0	-0.1	11.2	8.0
3105 TT	Win Semi	151.0	U/P	2,049	4.26	8.44	35.5	17.9	1.7	1.6	1.7	3.4	5.2	9.7	11.7	8.6
Foundry average							**20.5**	**14.1**	**2.1**	**1.9**	**2.0**	**2.5**	**10.8**	**13.6**	**9.2**	**7.5**
IDM																
005930 KS	Samsung	73,900	BUY	333,987	3,967	6,940	18.6	10.6	1.3	1.2	2.0	2.0	7.4	12.0	6.2	4.4
INTC US	Intel	47.1	Neutral	198,658	1.45	2.00	32.5	23.6	1.5	1.6	1.1	1.1	4.9	6.6	11.5	9.3
TXN US	Texas Instruments	164.9	Neutral	149,736	6.15	6.24	26.8	26.4	8.5	8.5	3.4	3.7	32.7	32.4	17.9	14.9
IFX GY	Infineon	34.2	BUY	48,870	2.37	2.95	14.4	11.6	2.3	2.0	1.1	1.2	17.0	18.5	8.0	6.5
IDM average							**23.1**	**18.1**	**3.4**	**3.3**	**1.9**	**2.0**	**15.5**	**17.4**	**10.9**	**8.8**
Fabless																
NVDA US	NVIDIA	547.1	BUY	1,351,337	12.28	20.46	44.6	26.7	33.1	17.3	0.0	0.0	97.3	85.6	37.1	22.7
AVGO US	Broadcom	1,108	BUY	518,550	46.72	56.37	23.7	19.7	14.9	11.3	1.9	2.1	77.7	68.5	19.3	16.2
QCOM US	Qualcomm	140.2	BUY	156,043	9.18	10.70	15.3	13.1	6.0	4.8	2.3	2.3	43.1	40.6	15.2	13.2
AMD US	AMD	146.6	BUY	236,768	3.88	5.12	37.8	28.6	4.0	3.6	0.0	0.0	10.9	13.2	22.8	18.8
Fabless average							**30.3**	**22.0**	**14.5**	**9.3**	**1.1**	**1.1**	**57.3**	**52.0**	**23.6**	**17.7**
Semi equipment makers																
ASML NA	ASML	652.6	BUY	288,292	19.93	27.97	32.7	23.3	20.3	18.1	1.1	1.2	62.0	81.0	26.5	19.6
AMAT US	Applied Material	151.3	BUY	125,699	7.39	8.44	20.5	17.9	6.3	5.2	0.9	1.2	34.2	31.8	17.3	15.4
LRCX US	Lam Research	759.7	BUY	100,118	27.68	31.62	27.4	24.0	12.7	12.5	1.1	1.2	45.0	49.9	21.9	19.9
8035 JP	Tokyo Electron	26,245	BUY	85,107	691	913	38.0	28.7	7.4	6.4	1.3	1.7	19.8	24.0	24.7	18.8
KLAC US	KLA Corp	560.6	BUY	76,205	23.30	25.88	24.1	21.7	20.3	17.0	1.0	1.2	94.9	84.2	18.3	17.1
Semi equipment average							**28.5**	**23.1**	**13.4**	**11.8**	**1.1**	**1.3**	**51.2**	**54.2**	**21.7**	**18.2**

Source: BofA Global Research estimates, company data, Bloomberg; "NC" = not covered

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Exhibit 65: Acronyms
We provide acronyms and the corresponding full names in the table below

Acronym	Full name	Acronym	Full name	Acronym	Full name
ADAS	Advanced Driver Assistance System	GPM	Gross Profit Margin	OPM	Operating Profit Margin
AI	Artificial Intelligence	GPU	Graphic Processing Unit	OSAT	Outsourced Semiconductor Assembly/Testing
AP	Application Processor	HPC	High-Performance Computing	PC	Personal Computer
ASIC	Application Specific Integrated Circuit	I/O	Input/Output	RF	Radio Frequency
ASP	Average Selling Price	IC	Integrated Circuit	S/D	Supply/Demand
CoWoS	Complementary Metal Oxide Semiconductor	IDM	Integrated Device Manufacturer	SoC	System-on-Chip
CPU	Central Processing Unit	InFO	Integrated Fan-Ou	SoIC	System-on-Integrated-Chip
DCU	Domain Controller Unit	MCU	Microcontroller Unit	T-con	Timing Controller
DDI	Display Driver IC	NB	Notebook	TPU	Tensor Processing Unit
FPGA	Field-Programmable Gate Array	NPM	Net Profit Margin	UTR	Utilization Rate
FX	Foreign Exchange Rate	OLED	Organic Light-Emitting Diode		

Source: BofA Global Research

Price objective basis & risk

Taiwan Semiconductor Manufacturing Co. (TSMWF / TSM)

We value TSMC at NT$760 per share (US$130 per ADR), based on 18x 2H24-1H25E P/E, or slightly above its five-year average P/E and SOX index's ten-year average P/E, given the structural long-term opportunities. We expect the valuation to be underpinned by its stronger industry position especially in leading edge technology, improved earnings quality, and subsequently FCF/dividend upside.

Downside risks are (1) greater-than-expected slowdown in global smartphone/consumer electronics demand, (2) Intel's potential insourcing strategy and ambitions in foundry service, and (3) execution risks on advanced nodes.

Analyst Certification

I, Brad Lin, hereby certify that the views expressed in this research report accurately reflect my personal views about the subject securities and issuers. I also certify that no part of my compensation was, is, or will be, directly or indirectly, related to the specific recommendations or view expressed in this research report.

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BofA Securities is currently acting as financial advisor to Intel Corp in connection with its sale of a minority stake in IMS Nanofabrication GmbH to Taiwan Semiconductor Manufacturing Co Ltd, which was announced on September 12, 2023.

APR - Semiconductor Coverage Cluster

Investment rating	Company	BofA Ticker	Bloomberg symbol	Analyst
BUY				
	Alchip	ALCPF	3661 TT	Mike Yang
	ASE Technology Holding	XSRIF	3711 TT	Brad Lin
	ASE Technology Holding -ADR	ASX	ASX US	Brad Lin
	ASMPT	ASMVF	522 HK	Simon Woo, CFA
	Crystal Clear	XPPTF	300655 CH	Dai Shen

APR - Semiconductor Coverage Cluster

Investment rating	Company	BofA Ticker	Bloomberg symbol	Analyst
	eMemory	XYLWF	3529 TT	Mike Yang
	Faraday	FDYTF	3035 TT	Mike Yang
	Global Unichip Corp.	GBUHF	3443 TT	Mike Yang
	GlobalWafers	XWLFF	6488 TT	Brad Lin
	Hwatsing Technology	XSNIF	688120 CH	Dai Shen
	JCET Group Co Ltd	XJIEF	600584 CH	Mike Yang
	Kingsemi	XKSQF	688037 CH	Dai Shen
	LX Semicon	XLXSF	108320 KS	Simon Woo, CFA
	Maxscend	XMXSF	300782 CH	Daley Li, CFA
	MediaTek	MDTKF	2454 TT	Brad Lin
	Montage Technology	XRDFF	688008 CH	Daley Li, CFA
	Nanya Technology	NNYAF	2408 TT	Simon Woo, CFA
	Novatek	NVKMF	3034 TT	Brad Lin
	Parade	PRDWF	4966 TT	Mike Yang
	Realtek	RLTKF	2379 TT	Brad Lin
	Samsung Elec -G	SSNHZ	SMSN LI	Simon Woo, CFA
	Samsung Electronics	SSNLF	005930 KS	Simon Woo, CFA
	Samsung Electronics Preferred	SSNNF	005935 KS	Simon Woo, CFA
	Silicon Motion	SIMO	SIMO US	Simon Woo, CFA
	SK Hynix	HXSCF	000660 KS	Simon Woo, CFA
	Taiwan Semiconductor Manufacturing Co.	TSM	TSM US	Brad Lin
	Taiwan Semiconductor Manufacturing Co.	TSMWF	2330 TT	Brad Lin
	United Microelectronics Corp.	XUMIF	2303 TT	Brad Lin
	United Microelectronics Corp.	UMC	UMC US	Brad Lin
	Will Semiconductor	XXHQF	603501 CH	Dai Shen
	Winbond Electronics	WBEKF	2344 TT	Dai Shen
	Wonik IPS	XRHQF	240810 KS	Simon Woo, CFA
NEUTRAL				
	Macronix International	MXICF	2337 TT	Dai Shen
	Powertech Technology	XPPZF	6239 TT	Simon Woo, CFA
	Soulbrain	XSBOF	357780 KS	Simon Woo, CFA
	Vanguard International Semiconductor Co	VGILF	5347 TT	Mike Yang
UNDERPERFORM				
	ASMedia Technology Inc.	XZSFF	5269 TT	Mike Yang
	Aspeed	XLKMF	5274 TT	Mike Yang
	GigaDevice	XGXIF	603986 CH	Daley Li, CFA
	Hangzhou Silan Microelectronics	XDFRF	600460 CH	Mike Yang
	Hua Hong Semi	HHUSF	1347 HK	Mike Yang
	Ingenic	XISCF	300223 CH	Dai Shen
	Lion Electronics	XDHFF	605358 CH	Dai Shen
	Phison Electronics	PISNF	8299 TT	Simon Woo, CFA
	Powerchip Semiconductor Manufacturing Co	XCHPF	6770 TT	Mike Yang
	Shenzhen Goodix	XQPLF	603160 CH	Mike Yang
	Silergy Corp.	SLEGF	6415 TT	Brad Lin
	VeriSilicon	XMLZF	688521 CH	Mike Yang
	Win Semiconductors	XWIIF	3105 TT	Brad Lin

*iQ*method℠ **Measures Definitions**

Business Performance	Numerator	Denominator
Return On Capital Employed	NOPAT = (EBIT + Interest Income) × (1 − Tax Rate) + Goodwill Amortization	Total Assets − Current Liabilities + ST Debt + Accumulated Goodwill Amortization
Return On Equity	Net Income	Shareholders' Equity
Operating Margin	Operating Profit	Sales
Earnings Growth	Expected 5 Year CAGR From Latest Actual	N/A
Free Cash Flow	Cash Flow From Operations − Total Capex	N/A

Quality of Earnings	Numerator	Denominator
Cash Realization Ratio	Cash Flow From Operations	Net Income
Asset Replacement Ratio	Capex	Depreciation
Tax Rate	Tax Charge	Pre-Tax Income
Net Debt-To-Equity Ratio	Net Debt = Total Debt − Cash & Equivalents	Total Equity
Interest Cover	EBIT	Interest Expense

Valuation Toolkit	Numerator	Denominator
Price / Earnings Ratio	Current Share Price	Diluted Earnings Per Share (Basis As Specified)
Price / Book Value	Current Share Price	Shareholders' Equity / Current Basic Shares
Dividend Yield	Annualised Declared Cash Dividend	Current Share Price
Free Cash Flow Yield	Cash Flow From Operations − Total Capex	Market Cap = Current Share Price × Current Basic Shares
Enterprise Value / Sales	EV = Current Share Price × Current Shares + Minority Equity + Net Debt + Other LT Liabilities	Sales
EV / EBITDA	Enterprise Value	Basic EBIT + Depreciation + Amortization

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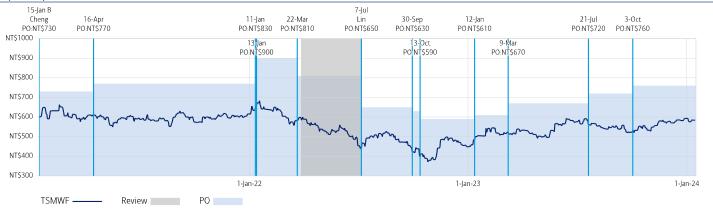
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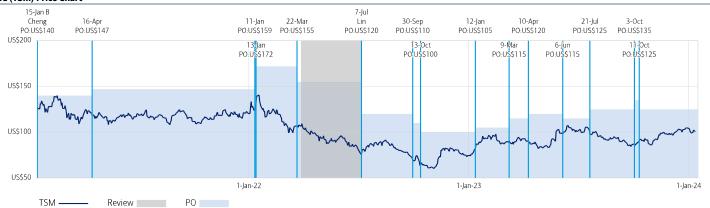
Disclosures

Important Disclosures

TSMC (TSMWF) Price Chart

TSMWF —— Review ▧ PO ▧

B: Buy, N: Neutral, U: Underperform, PO: Price Objective, NA: No longer valid, NR: No Rating

The Investment Opinion System is contained at the end of the report under the heading "Fundamental Equity Opinion Key". Dark grey shading indicates the security is restricted with the opinion suspended. Medium grey shading indicates the security is under review with the opinion withdrawn. Light grey shading indicates the security is not covered. Chart is current as of a date no more than one trading day prior to the date of the report.

TSMC (TSM) Price Chart

TSM —— Review ▧ PO ▧

B: Buy, N: Neutral, U: Underperform, PO: Price Objective, NA: No longer valid, NR: No Rating

The Investment Opinion System is contained at the end of the report under the heading "Fundamental Equity Opinion Key". Dark grey shading indicates the security is restricted with the opinion suspended. Medium grey shading indicates the security is under review with the opinion withdrawn. Light grey shading indicates the security is not covered. Chart is current as of a date no more than one trading day prior to the date of the report.

Equity Investment Rating Distribution: Technology Group (as of 31 Dec 2023)

Coverage Universe	Count	Percent	Inv. Banking Relationships [R1]	Count	Percent
Buy	215	53.09%	Buy	111	51.63%
Hold	97	23.95%	Hold	45	46.39%
Sell	93	22.96%	Sell	24	25.81%

Equity Investment Rating Distribution: Global Group (as of 31 Dec 2023)

Coverage Universe	Count	Percent	Inv. Banking Relationships [R1]	Count	Percent
Buy	1895	53.62%	Buy	1083	57.15%
Hold	832	23.54%	Hold	454	54.57%
Sell	807	22.84%	Sell	383	47.46%

[R1] Issuers that were investment banking clients of BofA Securities or one of its affiliates within the past 12 months. For purposes of this Investment Rating Distribution, the coverage universe includes only stocks. A stock rated Neutral is included as a Hold, and a stock rated Underperform is included as a Sell.

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Investment rating	Total return expectation (within 12-month period of date of initial rating)	Ratings dispersion guidelines for coverage cluster[R2]
Buy	≥ 10%	≤ 70%
Neutral	≥ 0%	≤ 30%
Underperform	N/A	≥ 20%

[R2]Ratings dispersions may vary from time to time where BofA Global Research believes it better reflects the investment prospects of stocks in a Coverage Cluster.

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