The program provides access to TSMC silicon process technologies for digital, analog/mixed-signal circuits, RF designs and micro-electromechanical system designs. Participants in the TSMC University Shuttle Program include major university research groups worldwide. TSMC and the University Shuttle Program participants achieve "win-win" collaboration through the program, which allows graduate students to implement exciting designs and achieve silicon proof points for innovations in various end-applications.

5.2.7 Future R&D Plans

To maintain and strengthen TSMC's technology leadership, the Company plans to continue investing heavily in R&D. In addition to 10nm and 7nm CMOS nodes in the pipeline, the Company's reinforced exploratory R&D work is on track to establish a solid foundation to feed into technology platforms beyond the 7nm node. The Company's exploratory work focuses on new transistors and technologies, such as 3D structures, strained-layer CMOS, high-mobility materials and novel 3D IC devices. These studies emphasize innovation and are guided by deep understanding of fundamental physics of nanometer CMOS transistors and related technologies. The Company also continues to collaborate with external research bodies from academia and industry consortia alike with the goal of extending Moore's Law and paving the road to future cost-effective technologies and manufacturing solutions for its customers.

With a highly competent and dedicated R&D team and its unwavering commitment to innovation, TSMC is confident in its ability to deliver the best and most cost-effective SoC technologies to its customers and to drive future business growth and profitability for years to come.

Summary of TSMC's Major Future R&D Projects

Project Name	Description	Risk Production (Estimated Target Schedule)
10nm logic platform technology and applications	3rd generation FinFET CMOS platform technology for SoC	2016
7nm logic platform technology and applications	4th generation FinFET CMOS platform technology for SoC	2017
3D IC	Cost-effective solution with better form factor and performance for SiP	2016 ~ 2017
Next-generation lithography	EUV and multiple e-beam to extend Moore's Law	2016 ~ 2019
Long-term research	Specialty SoC technology (including new NVM, MEMS, RF, analog) and transistors for 5nm node and beyond	2015 ~ 2019

The projects above accounted for roughly 70% of the total R&D budget in 2016, estimated to be around 8% of 2016 revenue.

5.3 Manufacturing Excellence

5.3.1 GIGAFAB® Facilities

Maintaining dependable capacity is a key part of TSMC's manufacturing strategy. The Company currently operates three 12-inch GIGAFAB® facilities – Fab 12, Fab 14, and Fab 15. The combined capacity of the three facilities exceeded six million 12-inch wafers in 2015. Production within these three facilities supports 0.13μm, 90nm, 65nm, 40nm, 28nm, 20nm, and 16nm process technologies, including each technology's sub-nodes. An additional portion of the capacity is reserved for R&D work on leading-edge manufacturing technologies, which currently supports the technology development of the 10nm node and beyond.

TSMC has developed a centralized fab manufacturing management system (Super Manufacturing Platform, SMP) to provide customers with greater benefits in the form of more consistent quality and reliability, improved flexibility to cope with demand fluctuations, faster yield learning and time-to-volume, and lower-cost product requalification.

5.3.2 Engineering Performance Optimization

As a professional semiconductor manufacturing and service company with a diversified product portfolio, TSMC's unique manufacturing system is tailored to achieve production of high complexity with precise control and optimized efficiency. To achieve overall optimization of equipment, process and yield, TSMC has introduced engineering big data analysis and machine learning techniques and has applied statistical process control, advanced equipment control, advanced process control and circuit probing. To satisfy advanced and accurate process control and ensure stable production of high efficiency and effectiveness, the Company employs systems of engineering big data mining and analysis, intelligent tool tuning, and equipment chamber matching. Engineering analysis platform for decision making, integrated with intelligent operating systems to achieve self-diagnosis and self-reactive actions, has produced remarkable results in yield enhancement, workflow improvement, fault detection, cost reduction and R&D cycle decrement.

TSMC has further analyzed the correlation between physical measurement, Wafer Acceptance Test (WAT), defect test, Certificate of Assurance (CoA), circuit probe and production-related parameters, aiming to identify critical variables influencing product quality to optimize yield management and fulfill customers' special process requirements as well as diversified product demand simultaneously.

5.3.3 Lean and Intelligent Operations

TSMC continues to drive manufacturing excellence through lean and intelligent operations. The Company has developed a lean work in process (WIP) line management system to control WIP levels precisely and equip a flexible demand/capacity modeling system to agilely support customers' urgent demands and provide customers with accurate on-time delivery and best-in-class cycle time.

To continuously improve fab operating efficiency, TSMC has introduced Internet of Things (IoT) and intelligent mobile devices. The new applications help to improve data collecting, yield traceability, material transportation and workflow efficiency, especially at mature fabs.

Following its commitment to manufacturing excellence, TSMC has integrated the technology of advanced data analysis, smart diagnostic, self-reactive engine and operation knowledge to revolutionize the fab operation mode from "Auto" to "Intelligent," optimizing operating efficiency and quality, maximizing cost effectiveness and accelerating overall innovation.

5.3.4 Raw Materials and Supply Chain Risk Management

In 2015, TSMC continued to hold review meetings periodically with teams from operations, quality control and business to proactively identify and manage the risks of insufficient supply capacity, quality issues and supply chain interruption. TSMC also worked with its suppliers to enhance performance, quality, delivery and sustainability, as well as to support green procurement, environmental protection and safety.

Raw Materials Supply

Major Materials	Major Suppliers	Market Status	Procurement Strategy
Raw Wafers	F.S.T. S.E.H. Siltronic SUMCO SunEdison	These five suppliers together provide over 90% of the world's raw wafer supply. Each supplier has multiple manufacturing sites in order to meet customer demand, including plants in North America, Asia, and Europe.	•TSMC's suppliers of silicon wafers are required to pass stringent quality certification procedures. •TSMC procures wafers from multiple sources to ensure adequate supplies for volume manufacturing and to appropriately manage supply risk. •Raw wafer quality enhancement programs are in place to meet TSMC's technology advancement. •TSMC regularly reviews the quality, delivery, cost, sustainability and service performance of its wafer suppliers. The results of these reviews are incorporated into TSMC's subsequent purchasing decisions. •A periodic audit of each wafer supplier's quality assurance system ensures that TSMC can maintain the highest quality in its own products.
Chemicals	Air Products Ampoe Avantor BASF Entegris Hong-Kuang Kanto PPC SAFC Wah Lee	These nine companies are the major worldwide suppliers of chemicals.	•Most suppliers have relocated some of their operations closer to TSMC's major manufacturing facilities, thereby significantly improving procurement logistics. •Each supplier's products are regularly reviewed to ensure that TSMC's specifications are met and product quality is satisfactory.
Lithographic Materials	Dow JSR Merck Nissan Shin-Etsu Chemical Sumitomo T.O.K.	These seven companies are the major worldwide suppliers of lithographic materials.	•TSMC works closely with its suppliers to develop materials that meet all application and cost requirements. •TSMC and suppliers periodically conduct programs to improve their quality, delivery, sustainability and green policy, and to ensure continuous progress of TSMC's supply chain. •Some major suppliers have relocated or plan to duplicate their manufacturing sites closer to TSMC's major manufacturing facilities, thereby significantly improving procurement logistics and reducing supply risks.
Gases	Air Liquide Air Products Entegris Linde LienHwa OCI Materials Taiyo Nippon Sanso	These six companies are the major worldwide suppliers of specialty gases.	•The majority of the six suppliers are located in different geographic locations, which minimizes supply risk for TSMC. •TSMC conducts periodic audits to ensure that they meet TSMC's standards.
Slurry, Pad, Disk	3M Air Products Asahi Glass Cabot Microelectronics Dow Chemical Fujifilm Planar Solutions Fujimi Kinik Sumitomo	These nine companies are the major worldwide suppliers of CMP (Chemical Mechanical Polishing) materials.	•TSMC works closely with its suppliers to develop materials that meet all application and cost requirements. •TSMC and suppliers periodically conduct programs to improve their quality, delivery, sustainability and green policy, and to ensure continuous progress of TSMC's supply chain. •Most suppliers have relocated or duplicated their manufacturing sites closer to TSMC's major manufacturing facilities, thereby significantly improving procurement logistics and reducing supply risks.

Suppliers Accounted for at Least 10% of Annual Consolidated Net Procurement

Unit: NT$ thousands

Supplier	2015			2014		
	Procurement Amount	As % of 2015 Total Net Procurement	Relation to TSMC	Procurement Amount	As % of 2014 Total Net Procurement	Relation to TSMC
Company A	7,981,126	15%	None	8,496,410	17%	None
VIS	7,148,777	13%	Investee accounted for using equity method	7,424,566	14%	Investee accounted for using equity method
Company B	6,452,073	12%	None	6,147,991	12%	None
Company C	5,457,120	10%	None	4,598,275	9%	None
Company D	4,336,724	8%	None	5,471,062	11%	None
Others	22,323,841	42%		18,889,285	37%	
Total Net Procurement	53,699,661	100%		51,027,589	100%	

5.3.5 Quality and Reliability

TSMC's strong industry reputation stems from its commitment to provide customers with the highest-quality wafers and best service for their products. Quality and Reliability (Q&R) services aim to achieve "quality on demand" to fulfill customers' needs for time-to-market delivery, reliable quality, and market competitiveness over a broad range of products.

Q&R technical services assist customers in the technology developmental stages to design in superior product reliability. Since 2008, Q&R has worked with R&D to successfully establish and implement new qualification methodologies for High-k/Metal Gate (HKMG), and since 2013, for FinFET structures. In May 2012, Q&R began collaborating with Semiconductor Equipment and Material International (SEMI) through a joint IC Quality Committee to enhance product quality of the semiconductor supply chain. Recently, Q&R started working with R&D and the Backend Technology and Service Division to complete the Package-on-Package (PoP) technology development and in 2014 began outsourced production at major assembly and testing houses for mobile product applications. Since then, over-200 million PoP devices have been shipped to customers without major quality issues.

In 2014, Q&R conducted a deep-dive audit on new material suppliers for 20nm/16nm advanced technology and announced the incoming material quality requests to enhance the suppliers' delivery quality. In 2015, Q&R extended the audit scope to include 10nm advanced technology suppliers and encouraged these suppliers to join the National Quality Control Circle Competition for self-initiative quality improvement. Most advanced technology material suppliers have achieved the goal of three sigma process control. Q&R also implemented innovative statistical matching methodologies to enlarge the manufacturing window with better quality control. The scope of the methodology includes raw materials, facilities, metrology and process tools, wafer acceptance test (WAT) data and reliability performance. Since 2011, Q&R tightened the post-fab outgoing visual inspection criteria for wafer quality improvement to Acceptable Quality Level (AQL) 0.4% from AQL 0.65%.

To sustain production quality and minimize risk to customers when deviations occur, manufacturing quality monitoring and event management span all critical stages – from raw material supplies, mask making, and real-time in-process monitoring, to bumping, wafer sort and reliability performance. Failure analysis and material and chemical studies play important roles in maintaining TSMC quality. These capabilities are applied from the early stages of process development through assembly and packaging, including analysis of incoming materials, airborne molecular contaminants, in-depth materials characterization for process development and failure analysis of customer returns. In 2015, TSMC continued to invest aggressively in state-of-the-art technology for materials analysis including electron and ion microscopes and surface analysis equipment. This resulted in further improvement in TSMC world-class cycle times and capacity in the area of transmission electron microscopy (TEM). Given the changing needs of our customers and the importance of ensuring the quality of incoming chemicals and materials, TSMC has implemented technologies to improve detection of metal impurities with a stronger emphasis on dynamic fault isolation and design debugging capabilities including the successful launch of our first focused ion beam (FIB) system dedicated to circuit editing. As a result, the Company has improved its ability to detect metal contaminants in incoming chemicals down to the parts-per-trillion level in 2014. Furthermore, in collaboration with customers and suppliers, significant progress has been made in dynamic fault isolation, traditionally a domain of integrated device manufacturers and fabless companies. TSMC improved the efficiency of these types of analyses through automation in 2015. With the growing presence of TSMC in the integrated circuit packaging area, the Company also bolstered failure analysis capabilities for multichip packages. These efforts, including the addition of new capabilities, will continue into 2016.

By facilitating fine bump pitch lead-free backend solutions for customer products, TSMC helped achieve compliance with the electronic industry's lead-free and green IC package policies. By collaborating with the major outsource assembly and testing subcontractors, Q&R qualified and released Cu bump with elongated shape lead-free bumping and Cu bumping. This made possible lead-free Cu bump packages for 16nm FinFET technology products. It also enabled TSMC customers to introduce lead-free 16nm FinFET products with excellent assembly quality, and over 40 million units were delivered without major quality issues in 2015. Q&R also worked with R&D and qualified InFO technology through both component level and board level reliability validation to allow customer product implementation beginning in the fourth quarter of 2015. For mainstream technologies, Q&R qualified extreme low-leakage and high-endurance embedded Flash IP, Integrated Passive Device (IPD), and a hybrid of copper and copper-aluminum technology. Q&R continues to build reliability testing and monitoring to ensure excellent manufacturing quality of specialty technologies on automotive, high-voltage products, CMOS image sensors, embedded-Flash memory and micro-electro-mechanical system products.

Q&R is also responsible for leading the Company towards the ultimate goal of zero-defect production through the use of continuous improvement programs. Periodic customer feedback indicates that products shipped from TSMC have consistently met or exceeded their field quality and reliability requirements. In 2015, a third-party audit verified the effectiveness of TSMC quality management systems in compliance with ISO/TS 16949: 2009 and IECQ QC 080000: 2012 certificates requirements.

5.4 Customer Trust

5.4.1 Customers

TSMC's customers worldwide have a variety of successful product specialties and excellent performance records in various segments of the semiconductor industry. Customers include fabless semiconductor companies, systems companies, and integrated device manufacturers such as Advanced Micro Devices, Inc., Broadcom Corporation, Huawei Tech, Marvell Technology Group Ltd., MediaTek Inc., NVIDIA Corporation, NXP Semiconductors N.V., OmniVision Technologies Inc., Qualcomm Inc., Sony Corporation, Spreadtrum Communications, Inc. Texas Instruments Inc., and many more.

Customer Service

TSMC believes that providing superior service is critical to enhancing customer satisfaction and loyalty, which is very important to retaining existing customers, attracting new customers, and strengthening customer relationships. With a dedicated customer service team as the main contact window for coordination and facilitation, TSMC strives to provide world-class design support, mask making, wafer manufacturing, and backend services to achieve an optimum experience for customers and, in return, to gain customer trust and sustain company profitability.

To facilitate customer interaction and information access on a real-time basis, TSMC-Online offers a suite of web-based applications that provide an active role in design, engineering, and logistics collaborations. Customers have 24/7 access to critical information and customized reports. Design Collaboration focuses on content availability and accessibility, with close attention to complete, accurate, and current information at each level of the design life cycle. Engineering Collaboration includes online access to engineering lots, wafer yields, wafer acceptance test (WAT) analysis, and quality reliability data. Logistics Collaboration provides access to data on any given order status in wafer fabrication, backend process, and shipping.

Customer Satisfaction

To assess customer satisfaction and to ensure that our customer needs are appropriately understood, TSMC conducts the Annual Customer Satisfaction Survey (ACSS) with most active customers, either by web or interview through an independent consultancy.

Complementary to the survey, Quarterly Business Reviews (QBRs) are also conducted by the customer service team so that customers can give feedback to TSMC on a regular basis. Through surveys, feedback reviews and intensive interaction with customers, TSMC is able to maintain close touch for better service and collaboration.

Customer feedback is routinely reviewed and considered by executives and then developed into appropriate improvement plans, all-in-all becoming an integral part of the customer satisfaction process with a complete closed loop. TSMC has maintained a focus on customer survey data not only to evaluate past performance but also as a base to identify future focus areas. TSMC acts on the belief that customer satisfaction leads to loyalty, and customer loyalty leads to higher levels of retention and expansion.