China’s electronics and semiconductor industry, circa 1985, was enmeshed in a complex hierarchy

PRC President Jiang Zemin (served 1993-2003) in 1997:

“In reality, ...[history] shows that if a country has several group companies it will be assured of maintaining a certain market share and position in the international economic order. America, for example, relies on General Motors, Boeing, DuPont and a batch of other multinational companies. Japan relies on six large enterprise groups, and South Korea relies on ten large commercial groupings. ...Our nation’s position in the international economic order will be to a large extent determined by the position of our nation’s large enterprises and groups.”

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抓大放小

“Grasp the Large, Let Go of the Small”
Semiconductors are China’s largest import category, at ~14% of all imports, topping even oil

Sources: Natixis, CEIC
China has announced a new policy initiatives and funding to grow its IC industry

Current goals:
- US$150 billion fund to be “IC Superpower by 2020”
- IC industry is the top priority for the “Made in China 2025” initiative
  - From 2012-2017, design firms increased from 500 to 1200
- These initiatives seek to lure foreign companies, establish advanced facilities, develop the full semiconductor industry supply chain and attract talent

Questions:
- Do these state-funded, state-led initiatives work?
- If they “fail”, does “failing” mean zero or negative results?
- Why use state firms for these initiatives, when private firms are more efficient/innovative? (capital, large enterprises, attract full value chain...yes, inefficient, but when will small firms emerge/succeed/grow?)
China’s top priorities for “Made in China 2025”

1. **Next-generation information technology (IT)**
   - **Integrated circuits (IC) and specialized equipment**
     - Focus on raising the level of IC design; enhancement of the intellectual property (IP) core and design equipment; realization of breakthroughs in core general-purpose chip technology; and raise of the level of domestic chip applications and compatibility as well as high-density chip packages and 3D micro-package technology
   - **Telecommunications equipment**
     - Full acquisition of core technology for new types of calculation, high-speed connections, up-to-date storage, and systematized security as well as technology for 5G, etc.
   - **Operation systems and industrial software**
     - Development of basic industrial software such as operating systems for security fields

2. **High-end numerical control tools and robotics**
   - **High-end NC tools**
     - Development of sensor high-level mother machines, basic manufacturing equipment, and integrated manufacturing systems, etc.
   - **Robots**
     - Development of new robot products, standardization of robot production, promotion of modularization, and expansion of robot uses, in response to demand for robots related to autos, machinery, electronics, hazardous materials manufacturing, military demand for national defense, chemical engineering, and light industry and for robots related to healthcare, home services, education, and leisure

3. **Aerospace equipment**
   - **Aviation equipment**
     - Acceleration of R&D of large aircraft; timely launch of wide-body passenger aircraft R&D; development and encouragement of heavy-duty helicopters through international tie-ups; and promotion of industrialization of trunk/local carriers, helicopters and unmanned aircraft
   - **Space equipment**
     - Development and promotion of next-generation transport rockets and heavyweights as well as improvement of the navigation capacity in outer space

4. **Ocean engineering equipment and high-tech ships**
   - Promotion of deep-sea exploration and development and usage of marine resources as well as development and manufacturing of security equipment, important systems and specialized equipment for marine work
   - Promotion of development of and production processes for deep-sea space stations and large floating structures; formation of comprehensive capabilities for ocean development facilities; improvement of marine resource development capabilities; acquisition of construction technology for luxury cruise ships; and improvement of international competitiveness in high-tech ships such as LNG tankers

5. **Advanced railway equipment**
   - Acceleration of application of new materials, new technologies and new methods; emphasis on acquisition of technologies related to system security, energy saving and environmental conservation as well as digitalized intelligent networks; and development of advanced, safe, appropriate products and series of products that are lighter weight and modularized
   - Development of the next generation of green, intelligent, high-speed, high-load capacity rail transport equipment systems; provision of comprehensive solutions; and construction of globally advanced modern rail transport systems

6. **Energy-saving and new energy vehicles**
   - Continuous development and promotion of electric cars and fuel-cell vehicles; acquisition of core technology for low carbon, computerization and intelligence; and improvement of processes and industrialization of core technologies for power batteries, drive motors, high-performance internal combustion engines, advanced transmissions, lightweight materials, and intelligent control, etc.
   - Construction of a complete industrial system and development system from parts to finished vehicles; and reaching an international level in energy-saving and new energy vehicles in independent brands

7. **Power equipment**
   - Promotion of industrialization and applied pilot projects for large, advanced, clean coal-fired electric power units; and improvement of manufacturing capabilities for ultra-large capacity hydropower generation units, nuclear power generation units, and heavy-duty industrial combustion turbines
   - Development and promotion of new energy and renewable energy equipment, advanced energy storage devices, substation transmission equipment for smart grids, and electric power equipment for user terminals
   - Manufacturing, securing of applied technology for, and construction of industrial capability for core equipment and materials such as high output electronic components and high-temperature superconducting materials

8. **Agricultural machinery**
   - Fluency promotion of advanced agricultural machinery for major production processes such as selective breeding, tillage, cultivation, management, harvesting and storing of large-lot foods and strategic economic crops such as staple foods, cotton, oil and sugar
   - Accelerated development of high-end agricultural equipment and critical components such as large tractors, multi-use agricultural equipment, and large, high-performance combines

9. **New materials**
   - Priority promotion of special metal functional materials, high-performance structural materials; functional polymer materials, special inorganic non-metallic materials, and advanced composite materials; acceleration of development of core technologies and equipment for tip smelting, solid casting, chemical vapor deposition, 3D processing, and new high-performance synthetic materials equipment; strengthening of basic research and system development; and overcoming of bottlenecks in industrialization
   - Promotion of development of, and assimilation and development of, special new materials for the military and civilians; and development and promotion of frontier materials such as superconducting materials, nano materials, graphene and bio-functional materials

10. **Biomedicine and high-performance medical devices**
    - Development and promotion of chemicals, Chinese herbal medicines, and new biotech drugs to combat serious disease; priority development of new mechanisms, new target chemicals, antibodies, antibody drug conjugates, new vaccinations, good new Chinese herbal medicines, and unique new therapeutic drugs
    - Improvement of the development capabilities and industrialization level of medical equipment; and promotion and development of advanced medical examination equipment such as video equipment and medical robots

Source: Abstracted from and prepared based on “Made in China 2025” promulgated by the State Council of China (May 19, 2015)
By revenue, China’s semiconductor industry is still much smaller than other major economies, despite China having the largest market (demand/use) for semiconductors.
By market value, China’s largest semiconductor firms are still much smaller than the largest U.S. companies.
The semiconductor industry has three major sectors, with differing value.

- **IC industry sectors:**
  - Design
  - Manufacturing: ("Fabrication" in a "Foundry")
  - P.A.T.: (Packaging, Assembly, Test)
Industry growth and global integration has resulted in thousands of Chinese personnel gaining valuable experience

As early as 2005, 18 of the world’s 25 semiconductor companies had R&D sites in China

Source: CCID, CSIA
China’s Economy:
Growth and Global Connections

Case Study:
State Sector Reforms and Evolution in the Semiconductor Industry
SOE Reforms: Case Study in Semiconductor Industry

PKU Globex
How did China develop the semiconductor industry it has today?

- Specific industries are illustrative of industry changes
  - 5YP by industry
  - Take-off by industry
  - One industry may help us understand groups of industries

- Main findings: interplay of SLD and “enterprise-led development”
  - Initially one-off efforts, then enterprise-based learning, then industry-wide policies
  - Different than general SOE reforms
  - Results were significant, but behind the vanguard, incremental, and organizational (vs tech)

One-off State Investments

1990s

Enterprise-based Learning
(in selected state-invested enterprises)

2000s

New Industry-wide Policies for ALL firms
China’s electronics and semiconductor industry, circa 1985, was enmeshed in a complex hierarchy

Importantly, in parallel with general SOE reforms, a new leading group made plans to invest in specific electronics industry projects

- 1982, new leading group, strategy of “Control Fragmentation, Control Chaos (治散, 治乱)”
  - Funds for 33 sites for new equip, but little success

- 1983, strategy of “Build 2 Bases and 1 Point”

- 1985, new guidelines
  - Focus on applications, foreign tech, and whole industry chain, with mfg emphasis
  - Use markets/competition, use national projects for large investments
  - Get funding through competitive bids and foreign capital

- 1986, “divestiture” of production & research units

- 1989,
  - Allocated RMB5b for 2 bases, 5 key enterprises
  - The #742 Factory selected to anchor the South Base, pursue 1 micron production, and (hopefully) be China’s “1st world-class IDM”

Officials hoped that one functioning IDM would attract a full industry chain, including both domestic and foreign firms
An overview of China’s major semiconductor projects and enterprises which led to today’s industry

- **Project 908**
  - Huajing, Inst 24
  - w/ ATT and CSMC
  - SOE (>JV)
  - IDM
  - Wuxi, est 1989

- **Project 909**
  - Huahong-NEC
  - JV with Japan
  - IDM
  - Shanghai, est 1994

- **SMIC**
  - WFOE, but “Chinese” w/ Taiwanese Mgmt
  - Foundry
  - Shanghai, est 1999

3 Other Sino-Foreign JVs (w/ Alcatel, Philips, NEC)

Electronics OEMs and ODMs increase in China

Foreign Firms bring Pak-Assy-Test to China

While ramping up semiconductor production, China’s *market* for semiconductors was growing
An overview of the semiconductor and electronics industry

- Semiconductor companies used to be “IDMs” (Integrated Device Manufacturer, e.g., Intel, Samsung, etc.)
- But vertical integration gave way to sectors by late 1990s, e.g., Freescale came out of Motorola for design
- IC industry sectors:

  - Design
  - Manufacturing: (“Fabrication” in a “Foundry”)
  - P.A.T.: (Packaging, Assembly, Test)

- Semiconductors in the broader electronics supply chain:

  - Semiconductor Cos. (ICs or discreet devices)
  - EMS (ECM) or ODM (often in China)
  - OEM (global brands, e.g., Apple)
Project 908 at Huajing remained unfunded for over 5 years

Obstacles, 1989-1996

- Funding
- Timing
- Technology and organization
- Foreign challengers
- Management

Lacking funding, equipment, and production, Project 908 was called a failure, and locals protested the once renowned Huajing.
Ultimately, Huajing’s managers made major operational changes

*Enterprise Solutions at Huajing, 1997-2002*

- From old management to new
- From enterprise to individual accounting units
- Using Taiwanese managers and tech (via JV) and the foundry model
- From vertical integration to sectoral businesses
- From central to municipal control, from debt to stock
- From Huajing to China Resources

The lessons and changes at Huajing informed Project 909 and previewed transitions in the industry
Huajing’s revenues increased significantly from 1995, and it remains one of China’s largest semiconductor companies

Estimates of Huajing-affiliated Organizations’ Revenues in US$ millions

These estimates are based on ratios of revenues among Huajing-affiliated organizations. Since 2008, Huajing-affiliated organizations have combined financial statements under CRM, but previous years are estimated based on Huajing data from earlier years.

Sources include:
CRM (China Resources Microelectronics) annual reports.
Chinese leaders instigated Project 909 in 1995

- Why a capital-intensive project in a rapidly advancing, competitive industry?
  - Existing enterprises need to upgrade production, growing market, use shop-floor to catch-up, no firms with necessary capital nor capital markets
  - Not due to the performance of state firms nor import-substitution nor foreign exclusion

- Approval, funding, timing
  - Leaders: Premier Li Peng, President Jiang Zemin, Minister Hu (MEI), and Mayor Xu
  - US$2b, ~7% of 1995 military budget, initially US$500m
  - MEI got money from Premier’s Fund, didn’t need multiple approvals
  - In 4 months, State Council and National Planning Committee approved/funded 909

- Lessons from 908 (with over 30 Huajing staff):
  - Can’t merely import production lines, need expertise, maintenance, training, etc.
  - Don’t pursue leading edge tech, it changes too fast, and China’s market is low/med
  - Funding is not enough, need international talent and capital, need talent and designs from start, “bring in any willing foreign partners for participation”

908 was production focused, but 909 would be production, design, talent, and market focused
Yet, 909 leaders had difficulty attracting a foreign partner

- **Goals:**
  - A functioning IDM would attract full industry chain, includes domestic & foreign firms
  - Serve China’s market, revenue for virtuous cycle of upgrading, market-led vs tech-led

- **Potential partners:**
  - Contacted 30-40 potential foreign partners
  - Response: no business plan, no revenues, investment is loans, 908 “failed,” no mgmt team, 20 yrs behind global tech, make mostly discrete devices, tough policy environment
  - 909 recruited from Huajing, across China, and CAS; offered large comp to foreigners

- **Breakthrough:**
  - Connect negotiations & market: offer partners newly state controlled IC card market
  - 5 firms negotiate for over a year, resulting in NEC as partner in 1997

- **NEC JV:** would supply the GM, run sales & marketing, provide tech and market
  - Producing in 1999, claimed profits in 2000
  - Adopted the foundry model (90% in ’03), developed IP with foreign partners

909 was more successful than 908, but China’s (1990s) policy environment was a problem during negotiations and operations
These enterprise-based experiences in ‘90s ultimately led to industry-wide policy changes via “Document 18” in mid 2000

Enterprise obstacles in 1990s:
- Multi-step approval processes
- Inconsistent and high importation costs and tax policies
- Large black market for smuggled electronic components
- Limited access to foreign capital

“One-offs”: Enterprises got “one-off” preferential tax and tariff exemptions, subsidies, etc., but making such arrangements was not transparent nor predictable

- Easing firm and branch formation
- Clarifying and decreasing taxation
- Encouraging foreign investment and trade
- Increasing capital sources and availability
- Protecting IP (?)

WTO agreements further improved policies by 2005, but production had been ramping up from 1995 and ongoing Chinese enterprises were established
2016: China is 59% of global semiconductor market & 16% of production, with design being the fastest growing sector.

China's market was less than 2% of the global semiconductor market in 1995. China's market was approximately 25% of the global semiconductor market in 2005 and was largest global market in 2008.

Sources:
2) Wang Yangyuan and Wang Yongwen, Wo Guo Jichengdianlu Chanye Fazhan Zhilu: cong Xiaofei Daguo Zouxiang Chanye Qiangguo 我国集成电路产业发展之路：从消费大国走向产业强国 (China's Integrated Circuit Industry Development Path: From a Big, Consuming Nation to a Strong, Industrial Nation), Kexue Chubanshe 科学出版社 (Science Press), 2008, page 123, per CSIA.
China's semiconductor production (blue) and market (red)

This graph is constructed from the following sources:
2) Wang Yangyuan and Wang Yongwen 王阳元 and 王永文, Wo Guo Jichengdianlu Chanye Fazhan Zhilu: cong Xiaofei Daguo Zouxiang Chanye Qiangguo 我国集成电路产业发展之路：从消费大国走向产业强国 (China’s Integrated Circuit Industry Development Path: From a Big, Consuming Nation to a Strong, Industrial Nation), Kexue Chubanshe 科学出版社 (Science Press), 2008, page 123, per CSIA.

Note: The PWC analyses uses data from CSIA and CCID, both associated with China's Ministry of the Information Industries. The data includes all enterprises operating in China, including foreign enterprises, not just Chinese owned or state owned enterprises.
China’s Economy: Growth and Global Connections

Case Study: State Sector Reforms and Evolution in the Semiconductor Industry
China’s Largest IC Design Companies by Revenue, 2017
By ElectronicDesign

HiSilicon Semiconductors - $3.87 billion (¥26 billion)
The largest Chinese chip supplier is this subsidiary of Huawei, the smartphone giant and the world’s largest maker of telecommunications gear. Based in the Chinese city of Shenzhen, it sells silicon for surveillance cameras, displays, set-top boxes, and wireless modems.

Tsinghua Unigroup - $1.86 billion (¥12.5 billion)
Tsinghua is something of a microcosm of China’s plans to boost its domestic semiconductor output. In 2013, it bought Spreadtrum Communications and RDA Microelectronics, two of China’s largest mobile chip firms, which have technology transfer deals with Intel. It also plans to invest $30 million in a memory chip factory in Nanjing. Tsinghua’s chairman Zhao Weiguo has pledged to invest $47 billion in the next three years to become the world’s third largest chipmaker behind Intel and Samsung. But other industry executives are not convinced that Tsinghua, which is backed by the government, can fill that role.

Omnivision - $1.39 billion (¥9 billion)
In 2015, Omnivision Technologies, which designs image sensors for smartphones and tablet cameras, sold itself to Chinese investors for around $1.9 billion. The company, founded in Santa Clara, Calif., makes most of its revenue from China, which boasts the largest smartphone market in the world.

ZTE Microelectronics - $892.57 million (¥6 billion)
The chip designer, based in Shenzhen, operates as a subsidiary of telecommunications giant ZTE, which stole headlines last year for running afoul of U.S. export sanctions. It incurred a $1.9 billion fine from the Commerce Department after selling telecommunications gear with American parts to Iran.

CEC Huada Semiconductor - $505.79 million (¥3.4 billion)
Huada primarily sells security chips for government access cards and SIM cards that telecommunications companies slip
into cellphones. In 2009, it became a subsidiary of China Electronics Corporation Holdings, which is directly run by the central government.

**Nari Smart Chip - $478.27 million (¥3.2 billion)**
Beijing Nari Zhixin Microelectronics Technology is similarly linked to the government through a cascade of subsidies. It sells security and communications chips for smart meters, industrial control systems, and railroad equipment. It supplies parts to its parent company, which in turn provides electric power equipment to its parent, State Grid Corporation of China, the country’s electric utility monopoly. Unsurprisingly, State Grid is owned by the state.

**Shenzen FocalTech - $446.28 million (¥3 billion)**
This is the Shenzhen subsidiary of FocalTech Systems, which was founded in California before merging with Taiwan’s Orise Technology in 2015. It makes controllers that measure pressure put onto touch screens, LCD drivers, and fingerprint sensors used in various electronic devices.

**Silan Microelectronics - around $342.15 million (¥2.3 billion)**
Silan Microelectronics, based in the city of Hangzhou, sells everything from microcontrollers to power management chips. Last year, the company announced that it would invest $120 million in a manufacturing plant with assistance from the Big Fund.

**Beijing ISSI - around $342.15 million (¥2.3 billion)**
Integrated Silicon Solution Incorporated sells SRAM, DRAM, and flash memory chips. In 2015, the Chinese investment firm, Uphill Investment, bought the fabless chipmaker founded almost thirty years ago in Milpitas, Calif.

**Datang Semiconductor - around $342.15 million (¥2.3 billion)**
This supplier is a subsidiary of the telecommunications giant Datang. It is more commonly known as Leadcore Technology, which was independent before being acquired in 2015. In January, it formed a new company with Qualcomm called JLQ Technology to devise wireless chips for smartphones and tablets.