Indigenous Innovation and its Effect on China's Semiconductor Industry

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1. China's "Indigenous innovation" dilemma

Indigenous innovation based on the idea that core technologies may not be transferred [Wassenaar*effect]

- Aims to replicate value chain in China
- Seeks to shift the balance from global technology sourcing to domestic R&D and innovation.

Yet, globalization of knowledge through global production & innovation networks enables Chinese firms to source core technologies and capabilities in an increasingly fine division of the value chain.

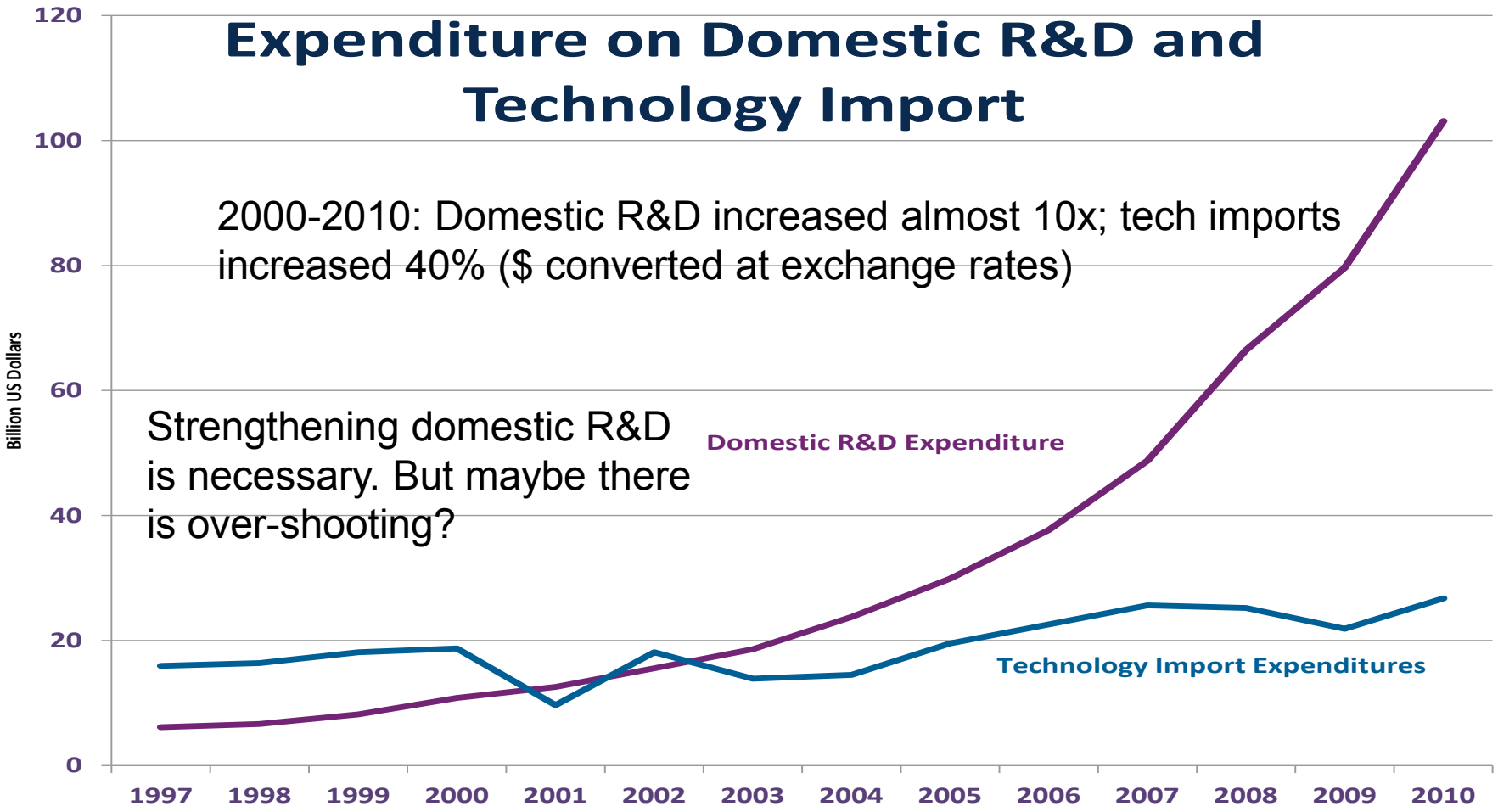
Two innovation strategies coexist, but with little interaction: <u>Indigenous innovation vs Global integration</u>

Can China combine the benefits of both innovation strategies?

For the US: Do we need to adjust our trade diplomacy strategy?

*http://www.wassenaar.org/controllists/index.html

"Indigenous Innovation" has changed the balance between global sourcing and domestic R&D



Ernst and Naughton 2012; China Statistical Yearbook 2012

2. China's semi industry - Achievements

- China's share in world semi consumption >47% (2003 <19%)
- Since 2003, China's domestic consumption market has made up > 34% of worldwide semiconductor market growth.
- China's share in world semi industry =12.2%(2000:2%)
- China's IC design ind'y has grown from < $200m in 2001 to > $7bn in 2011—a 45% compounded annual growth rate.
- Chinese IC design companies have ~ 8% of world IC design revenue
- SPA&T is #1*, domestically & internationally (ahead of Taiwan and Japan)
- Optical (LED), sensors & discrete devices approaching self-sufficiency

* = value added, production revenue, employees and manufacturing floor space

Co-shaper of market and standards for wireless communications

China as lead market has…

- three times as many mobile handset subscribers as in the US (> 1 bn to 331.6m)
- 22% of global smart phone market (US=16%)

China as co-shaper of standards

- SPRD and RDA have benefited from early integration into TD-SCDMA and TD-LTE standards
- Both standards have fostered the development of technical capabilities in China-based IC design companies. → **critical mass?**
- Global industry leaders (QCOM,BRCM, NVDA Marvell, INTC) are latecomers to TD standards and are constrained by high fixed costs. But they have other huge advantages (such as superior technology and system integration capacity).

2. China's semiconductor industry – Weaknesses

- The gap between Semi consumption & production keeps growing
- Semi trade deficit more than doubled since 2005 to $ 138bn in 2011 [growing imports of advanced ICs]
- Wafer fab – China still plays second fiddle
- Weak IC design capabilities
- Weak patent portfolio
- Support policies tend to result in periodic excess capacity
- Standard taker (with few exceptions)
- **Vicious circle***: As long as these weaknesses persist, the government will continue its efforts to increase local production and indigenous innovation.*

Domestic innovation barriers

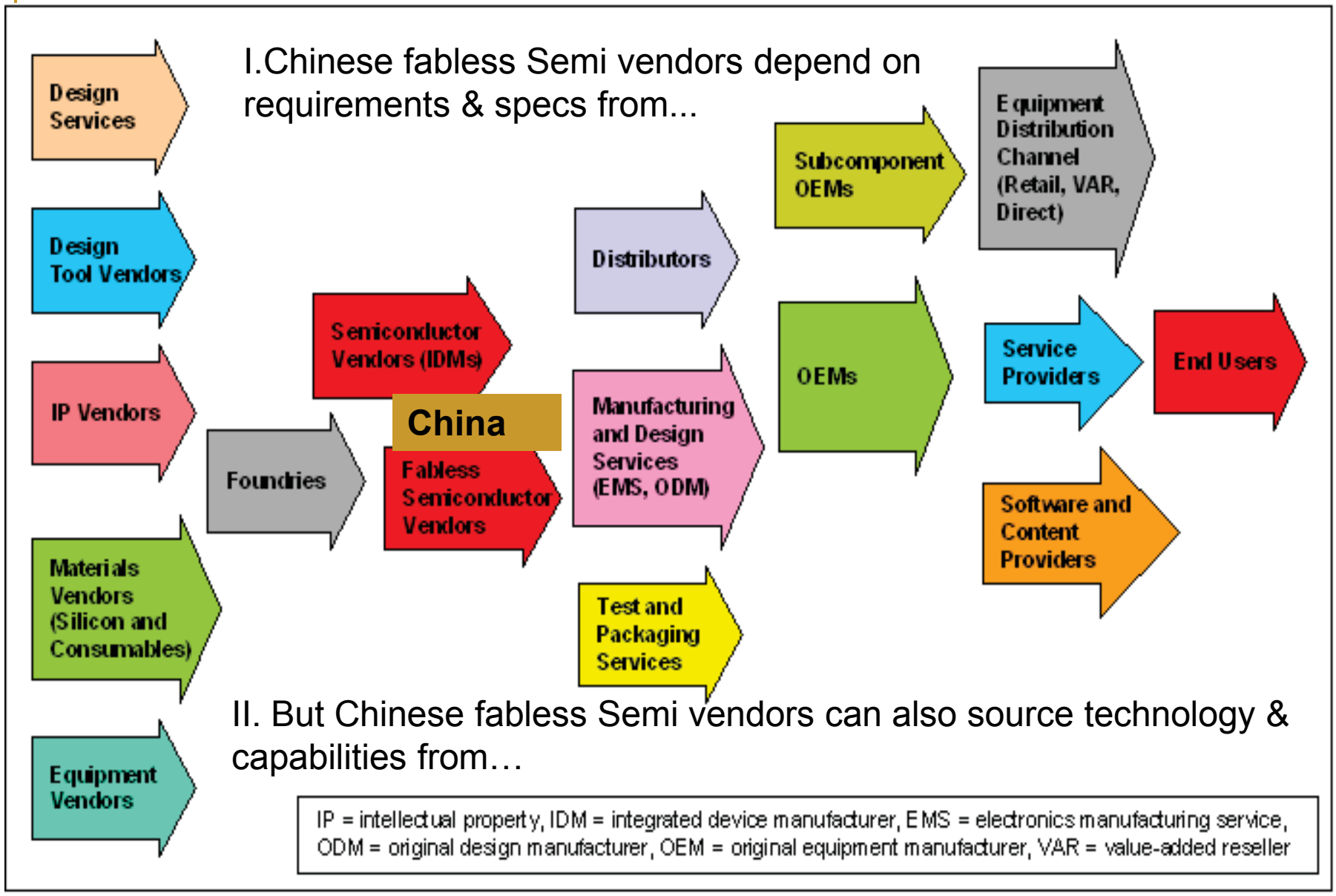
- Fragmented innovation system → inter-agency rivalries
- Quality problems in education; plagiarism in science & derivative research
- Top-down technology leapfrogging that neglects risks of ramping-up complex technology systems in record time
- Public R&D support and procurement privileges SOEs & neglects SMEs
- Weak IPR regime → disincentives for innovation
- Lists of "indigenous innovation" products used for government procurement focus on *existing* technologies and hence stifle innovation
- Weak complementary capabilities (legal; patent law; standardization; coordination of complex innovation networks; "integrated solutions"; advanced manufacturing)

3. Global value chain integration and innovation capacity - the Semiconductor story

China's indigenous innovation policy…

- fails to take into account how the deep integration into the global semiconductor value chain affects innovation strategy and capacity of Chinese firms
  - Positive: Deep global integration enables Chinese firms to engage in increasingly sophisticated forms of global technology sourcing.
  - Negative: Foreign firms dominate China's semi consumption and shape basic IC design decisions →*This constrains the demand for domestic innovation & the development of innovation capabilities*

Integration into the Semiconductor Value Chain



Global value chain integration lowers entry barriers for Chinese IC design firms

"The availability of IC design tools, semiconductor fab services, and open-source smartphone software [Android] allows Chinese firms to circumvent their weak spots and develop their strengths in hardware, IC design, and integration."

-Interview with Dr. Leo Li (CEO of Spreadtrum), June 29, 2012

Global value chain integration may constrain domestic innovation

- Demand: 2/3 of China's semi consumption goes into products assembled by foreign companies (OEMs; EMSs) in China for export → **foreign companies shape IC design decisions**
  - 2011: Semi consumption by Chinese OEMs (Huawei, Lenovo, Hai'er, ZTE etc) is increasing, but still accounts for only 11% of China's total semi consumption
- Supply: 8 global semi companies have been among the top 10 semi suppliers to China every year from 2003 to 2011
- Supply: heavy reliance on foreign foundries

Global value chain integration may constrain development of innovation capabilities

- Technology export restrictions on leading-edge technology slow-down the pace of catching-up [Wassenaar Agreement*]
- EDA: China is a user, not a producer
- Materials: Ditto
- Fab equipment: Ditto. Used equipment favored
- Lack of exciting projects for Chinese process & design engineers; limited learning opportunities

*http://www.wassenaar.org/controllists/index.html

Prospects…

- "Innovative China" has two faces that coexist, but with little interaction: **Indigenous Innovation scenario** versus **Global integration scenario.**
- For policy debates, this raises two important questions:
  - For China, the question is: **Can it combine the benefits of both innovation strategies?**
  - For the US: **What adjustments are necessary in our trade diplomacy strategy?**

4. Recent Policy Developments

- *State Council Notification on the Long-term Development Plan for Strategic Emerging Industries during the 12th Five Year Plan, July 7, 2012*
- *State Council Document 4 on Issuing Several Policies on Further Encouraging the Development of the Software and Integrated Circuit Industries*, 28 January 2011 [New Policy Document No.18]

ICs in the Strategic Emerging Industries Plan

Design at 22 nm

Build the entire value chain

专栏 5 电子核心基础产业发展路线图

时间节点	2015 年	2020 年
发展目标	高性能集成电路设计技术达到 22 纳米、大生产技术达到 12 英寸 28 纳米，掌握先进封装测试技术，初步形成集成电路制造装备与材料配套能力；新型平板显示面板满足国内彩电整机需求量的 80%以上，新一代显示技术取得突破；关键电子元器件自主保障能力明显提升；关键专用设备、仪器和材料研发和产业化取得突破。	掌握新一代半导体材料及器件的制造技术，集成电路设计、制造、封装测试技术达到国际先进水平；实现下一代显示器件与国际先进水平同步发展；新型关键元器件满足国内市场需求并具有国际竞争力；电子专用仪器设备和材料基本满足国内配套需要，形成核心竞争力。
重大行动	●关键技术开发：加快实施核心电子器件、高端通用芯片及基础软件产品科技重大专项和极大规模集成电路制造装备及成套工艺科技重大专项，重点开发移动互联、数模混合、信息安全、数字电视、射频识别（RFID）、传感器等芯片，推动 32/28 纳米先进工艺产业化，支持射频工艺、模拟工艺等特色工艺开发，大力发展先进封装和测试技术，加强 8-12 英寸生产线关键设备、仪器、材料的研发。支持半导体与光电子器件新材料制备技术，高世代 TFT-LCD 生产线工艺、制造装备及关键配套材料制备技术，高清晰超薄 PDP 及 OLED 等新型显示技术，以及新型电力电子器件关键技术的开发。 ●产业化：实施集成电路、新型平板显示创新发展工程；推进 LED、微机电系统（MEMS）、智能传感器、新型电力电子器件以及金属有机源化学气相沉积（MOCVD）装备等产业化。 ●创新能力建设：建设集成电路装备及其生产系统集成开发等领域公共技术服务平台，建设微机电系统开发与应用实验室，建设完善 LED、电力电子、智能传感器、光电子等领域工程实验室，建设平板显示共性技术研发及公共服务平台。 ●骨干企业培育：实施创新企业扶持计划，鼓励产业链上下游强强联合和兼并重组，支持基础产品企业与整机和应用企业建立创新联盟、创新发展促进中心等。	
重大政策	●细化和落实支持集成电路和平板显示产业发展的优惠政策，研究提出支持整机和元器件产品、集成电路设计和芯片制造联动发展的优惠政策，制定推动 LED 产品推广应用的政策措施。	

国务院关于印发“十二五”国家战略性新兴产业发展规划的通知

July 7, 2012

Ernst and Naughton, 2012

State Council Document 4 …

- increases the level of support from the government.
- promotes mergers and the creation of big firms that can be globally competitive.
- acknowledges that a focus on the development of IC **production** wasn't the right policy approach.
- highlights the critical role of companies that provide the high-value-added services for final products at the end of the value chain
- argues that China's huge market facilitates the creation of home-made standards and IP.
- supports 5 key industries as **lead users** for China's IC industry: the Internet of Things; Unified Broadband Networks; Automotive Electronics; LED Lighting; and Energy-saving Semiconductors (e.g. for Smart Grid)

State Council Document 4 on Issuing Several Policies on Further Encouraging the Development of the Software and Integrated Circuit Industries (28 January 2011)

Moving beyond the hardware manufacturing bias?

- Doc 4 reflects debates in EU (manuservices), US (integrated manufacturing, services and innovation) & Taiwan (servitization).
- It is encouraging to hear that China wants to move away from the hardware/leading edge technology bias. → *But how quickly can they implement such a dramatic shift?*
- The plans are written by smart people who are influenced by ideas elsewhere. They see the profit margins Apple commands.
- But these are ideas about how things *should* work, not necessarily instruments or plans that can affect outcomes.

Implementation barriers

- Have people on the ground, who are supposed to implement this policy shift, experienced a change of heart?
- China's service industry is still far behind international service standards. This reflects the continuing dominance of SOEs in China economy: they created monopolies which are very difficult to circumvent – thus they have little incentive to improve business models
- Little experience in China about needs of other markets, except for manufacturing. After-sales services are very poor across board.
- For vertical integration you need to own the brand name. **→There is still not a single Chinese semi company with a global brand name.**

Implications for US policy

- US Semi industry is still way ahead of China
- China's Semi industry continues to rely on US technology imports
- This has created a backlash in China - Recent policies seek to increase indigenous production and innovation
- We should not expect full convergence to US model → Limited convergence will go hand in hand with persistent diversity
- The real issue is: **Are we able to generate enough high-value jobs through exports of US technology to China?**

Establish reciprocity of rights and obligations

- Both the US and China need to accept that while our economic institutions are different, they are deeply interdependent.
- China must put something more substantial on the table to avoid increasing trade disputes.
- We are willing to accept the Chinese way of governing the economy - including all hidden subsidies - if we get what is first priority for us: **We need better IP protection, less technical problems with market access, and lower investment barriers throughout.**
- If we are able to sell our high value goods and services, we both win. China will get all the technologies they want and in parts still desperately need. We would get new well-paying quality jobs in the US that result from trade with China.

Q&A

Wafer fab – China still plays second fiddle

Current plus committed fabs → moderate impact

- China's share of total worldwide semiconductor wafer production could grow to 10.7% by 2015.
- China is way behind in process technology & wafer size
  - only 24% of its capacity is at the advanced <0.06µm node compared to a worldwide industry distribution of 44%.
  - 7.2% share in world 12'' capacity likely to decline
  - China continues to have **newer wafer fabrication plants with older technology** [*focus on LED; used equipment & technology]*
- ***Can access to TSMC,UMC etc compensate for China's wafer fab weakness?***

Weak patent portfolio

China's share of

- world semiconductor technology-focused patents increased from 13.4% in 2005 to 21.6% in 2009 - and was forecast to reach 33% in 2011.
- semiconductor patents that are being first issued in China has grown from zero in 2005 and 2006 to 24.1% in 2009

➢ *Innovation capacity in semiconductors is improving, but China still has a long way to go to catch up with the US.*

Derwent Worldwide Patent data

China's incomplete semi industry infrastructure

- Fabless IC design
- Fabs (IDMs; foundries)
- Tool providers
- Suppliers of materials (pure silicon wafers; chemicals; industrial gases)
- Software developers (IC design; production scheduling; testing)
- Research labs (materials science; device physics)

3 companies dominate China IC design industry

Company name	Rank	Sales revenue 2011 (US$M)	Change (2011/2010)
HiSilicon	1	1,032	58.1%
SPRD	2	663	79.6%
RDA	3	281	48.7%

Optical, Sensors, Discrete devices (OSD) – a more balanced pattern

Production/consumption

- Optical: -$374m (2005) → significant surplus in 2011
- Discrete devices: surplus of $1bn in 2011; surplus projected to increase to $ 7bn in 2014.

Trade balance

- Discrete devices (including LED) – a first time ever trade surplus in 2011: $16.2bn.
- This segment is approaching self-sufficiency.

Semiconductor wafer fabrication moves to Asia

Fabs that started operation

- 2011 total: 49 → China (26), Taiwan (7), Korea (3), **US (3)**
- 2011 & 2012 total: 81 → China (50), **US (6)**

Fabs under construction

- 2011 total: 27 → China (18); Taiwan (4); SEAsia (2); Japan (1); **US (1)**
- 2011 to 2013 total:42 → US (1)

Projected growth in SC fabrication capacity (2004-2013)

- China (583%); Korea (307%); Taiwan(228%); Japan (100%); **US (65%)**

SEMI World Fab Forecast report, 2012

Deep global integration – Global innovation networks (GINs)

- China is the largest 'net importer' of R&D
- … the third most important offshore R&D location for the 300 top R&D spending multinationals, after the United States and the United Kingdom*
- Foreign-invested enterprises (FIEs) account for 82% of China's high tech exports in 2010 (up from 79% in 2002)**

* Ernst, D., Testimony To the U.S.-China Economic and Security Review Commission, June 2011

** Congressional Research Service, *China's Economic Condition, June 2012*

2011 Top 25 Fabless IC Suppliers ($M)

2011 Rank	2010 Rank	2009 Rank	Company	Headquarters	2009 ($M)	2010 ($M)	% Change	2011 ($M)	% Change
1	1	1	Qualcomm	U.S.	6,409	7,204	12%	9,910	38%
2	2	3	Broadcom	U.S.	4,271	6,589	54%	7,160	9%
3	3	2	AMD	U.S.	5,403	6,494	20%	6,568	1%
4	6	5	Nvidia	U.S.	3,151	3,575	13%	3,939	10%
5	4	6	Marvell	U.S.	2,690	3,592	34%	3,445	-4%
6	5	4	MediaTek	Taiwan	3,500	3,590	3%	2,969	-17%
7	7	7	Xilinx	U.S.	1,699	2,311	36%	2,269	-2%
8	8	10	Altera	U.S.	1,196	1,954	63%	2,064	6%
9	9	8	LSI Corp.	U.S.	1,422	1,616	14%	2,042	26%
10	10	11	Avago	Singapore	858	1,187	38%	1,341	13%
11	13	12	MStar	Taiwan	838	1,065	27%	1,220	15%
12	11	13	Novatek	Taiwan	819	1,149	40%	1,198	4%
13	15	16	CSR	Europe	601	801	33%	845	5%
14	12	9	ST-Ericsson*	Europe	1,263	1,146	-9%	825	-28%
15	16	15	Realtek	Taiwan	615	706	15%	742	5%
16	17	17	HiSilicon	China	572	652	14%	710	9%
17	27	67	Spreadtrum	China	105	346	230%	674	95%
18	19	19	PMC-Sierra	U.S.	496	635	28%	654	3%
19	18	14	Himax	Taiwan	693	643	-7%	633	-2%
20	21	—	Lantiq	Europe	0	550	N/A	540	-2%
21	33	30	Dialog	Europe	218	297	36%	527	77%
22	22	21	Silicon Labs	U.S.	441	494	12%	492	0%
23	29	20	MegaChips	Japan	445	337	-24%	456	35%
24	23	24	Semtech	U.S.	254	403	59%	438	9%
25	24	23	SMSC	U.S.	283	397	40%	415	5%
Top 25 Total			—	—	38,242	47,733	25%	52,076	9%
Non-Top 25 Fabless			—	—	11,091	14,781	33%	12,811	-13%
Total Fabless			—	—	49,333	62,514	27%	64,887	4%

*Represents the 50% share not accounted for by ST.

Source: Company reports, IC Insights' *Strategic Reviews Database*

2011 Top 25 Fabless IC Suppliers Ranked by Growth Rate ($M)

2011 Rank	Company	Headquarters	2010 ($M)	2011 ($M)	% Change
1	Spreadtrum	China	346	674	95%
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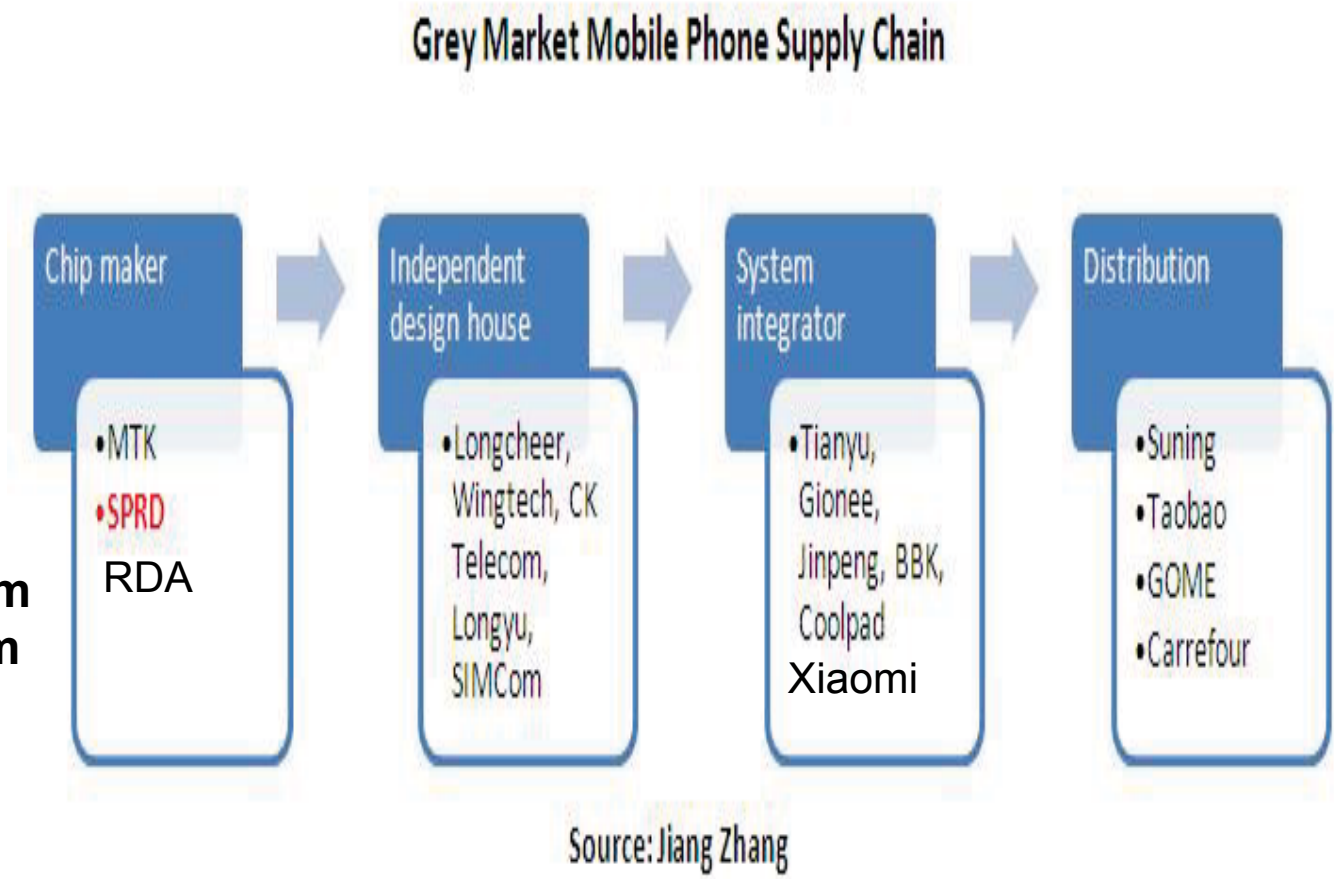
Disruption from below

- Global value chain integration can upset existing competitive order. This happened when Mediatek (Taiwan) overturned the order several years ago with comprehensive baseband chips.
- Mediatek enabled a new ecology of “Shanzhai” or white box producers. This disruption is about to happen again, as China moves up to 3G and 4G wireless communications.
- This also creates enormous downward pressure on prices and margins. → **Can any company make money producing ICs?** (Qualcomm?)

China's evolving "Shanzhai" Ecology



Plus:
Qualcomm
Broadcom
Nvidia
ARM